



Universidade de Aveiro Departamento de Engenharia Mecânica
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**PROJETO E FABRICO DE UM TRIBÓMETRO
BLOCO – DISCO**



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BLOCO – DISCO**

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia Mecânica, realizada sob a orientação científica do Prof. Doutor João Paulo Davim Tavares da Silva, Professor Associado com Agregação do Departamento de Engenharia Mecânica da Universidade de Aveiro

Dedico este trabalho aos meus pais pois foram eles que permitiram o meu sucesso nesta longa caminhada.

O júri

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Palavras-chave

Tribologia, atrito, desgaste, coeficiente de desgaste, velocidade de deslizamento, carga, projeto, tribómetro, bloco-disco.

Resumo

O presente trabalho compreende a elaboração de um projeto e fabrico de um tribómetro bloco-disco, económico e de fácil utilização, com o objetivo de realizar ensaios ao nível do desgaste recorrendo ao método perda de massa da amostra.

Sendo o estudo de diferentes materiais uma matéria importante a nível industrial, o atrito e o desgaste são os fatores mais abordados pois são os principais causadores de perda de energia em componentes e mecanismos, daí que o seu estudo seja extremamente necessário recorrendo-se muitas das vezes a tribómetros para melhor compreender o comportamento desses materiais.

A primeira fase do trabalho é dedicada à pesquisa enquanto que na segunda fase, analisa-se várias soluções possíveis para diferentes sistemas importantes ao funcionamento do equipamento, onde é realizada uma comparação entre elas permitindo a seleção da melhor solução. É também efetuado o dimensionamento de todos os componentes da máquina com recurso a programas de modelação 3D de modo a garantir que a máquina suportará todas as forças envolvidas aquando da realização de ensaios.

Na terceira etapa, surge o tribómetro. É exemplificado o processo de montagem e realizada uma avaliação das capacidades da máquina ao nível da gama de cargas e da velocidade de rotação.

Por fim, submete-se a máquina a testes utilizando discos de aço AISI 1045 e amostras de alumínio 1050. Relativamente aos resultados obtidos pode concluir-se que o tribómetro atingiu as expectativas uma vez que apresentou resultados na mesma ordem de grandeza de outras ligas de alumínio testadas na literatura.

Keywords

Tribology, friction, wear, wear coefficient, sliding speed, load, projet, tribometer, block-on-ring.

Abstract

This project focuses on designing and manufacturing a tribometer block-on-disc, economic and easy to use, with the purpose of performing wear tests using the method of mass loss of the sample.

Since the study of different materials is an important matter in industry, friction and wear are the most important factors because they are the main cause of energy loss in components and mechanisms. Hence, its study is extremely necessary and it commonly resorts to tribometers to better understand the behavior of these materials.

The first phase of the work is dedicated to the research while on the second phase, several possible solutions were analyzed for different systems necessary to the operation of the equipment. A comparison is made between them allowing the selection of the best solution.

All the components of the machine were dimensioned resorting to 3D modeling software to ensure that the machine will bear all the forces involved during the tests.

In the third stage, the tribometer construction is defined. The assembly process is characterized and the evaluation of the capacity of the machine was made concerning the load range and the speed of rotation.

Finally, the machine is subjected to tests using AISI 1045 steel discs and aluminum 1050 samples. Regarding the obtained results it is concluded that the tribometer achieved the goals because it presented results in the same order of magnitude of other alloys of Aluminum in the literature.

Índice

LISTA DE FIGURAS	v
LISTA DE TABELAS	ix
SIMBOLOS E ABREVIATURAS.....	xi
1 INTRODUÇÃO	3
PARTE I - REVISÃO BIBLIOGRÁFICA	
2 SISTEMAS TRIBOLÓGICOS	9
2.1 Atrito	10
2.2 Desgaste	12
2.2.1 Tipos e mecanismos de desgaste	13
2.2.2 Coeficiente e taxa de desgaste	17
2.3 Parâmetros que influenciam o comportamento tribológico de materiais ..	19
2.3.1 Rugosidade e Dureza	20
2.3.2 Velocidade de deslizamento	20
2.3.3 Carga.....	21
2.3.4 Temperatura	21
2.3.5 Lubrificação	22
2.3.6 Formação do filme	22
2.4 Tribómetros.....	23
2.5 Síntese	24
PARTE II - PROJETO	
3 ETAPAS DO PROJETO.....	27
3.1 Especificações e métodos	28
3.1.1 Carga aplicada.....	28
3.1.2 Movimento e gama de velocidades.....	29
3.1.3 Sistema de aquisição de velocidade.....	30
3.1.4 Geometria da amostra	31
3.1.5 Medição do desgaste	32
3.2 Estudo de soluções para o tribómetro idealizado.....	33
3.2.1 Estrutura.....	33

3.2.2	Sistema de fixação/alojamento da amostra	35
3.2.3	Sistema Aplicação de Carga	38
4	DIMENSIONAMENTO	41
4.1	Motor	41
4.2	Estrutura	45
4.3	Sistema de Aplicação de Carga	46
4.4	Veio principal	49
4.5	Rolamentos	50
4.6	Suporte da amostra.....	52
4.7	Simulação com todo o conjunto.....	55
4.8	Tribómetro – Solução Final	58
4.9	Síntese	59
PARTE III - TRIBÓMETRO		
5	CONSTRUÇÃO E MONTAGEM.....	63
5.1	Estrutura de suporte	63
5.2	Veio motor	65
5.3	Sistema aplicação de carga	65
5.4	Sistema de suporte da amostra.....	66
5.5	Montagem do tribómetro	67
5.5.1	Gama de cargas do tribómetro	70
5.6	Síntese	71
6	ENSAIOS E ANÁLISE DE RESULTADOS	73
6.1	Condições iniciais	74
6.2	Avaliação dos resultados	74
6.3	Perda de volume teórica vs. Perda de volume real	77
7	CONCLUSÕES.....	81
7.1	Trabalhos futuros	83
8	REFERÊNCIAS	87
9	ANEXOS.....	91
	ANEXO I – DataSheet Variador de frequência (parcial)	92

ANEXO II – DataSheet Motor Trifásico.....	92
ANEXO III – Desenhos Técnicos	92
ANEXO IV – Manual de Utilização do Tribómetro	92

LISTA DE FIGURAS

Figura 1-1 - Fatores que afetam um sistema tribológico (adaptado de J. Paulo Davim & A. Monteiro Baptista, 2013).....	4
Figura 2-1 - Esquema ilustrativo das etapas envolvidas na análise de desgaste (Adaptado de Bayer, 2002).....	13
Figura 2-2 - Interações tribológicas e mecanismos de desgaste (Baseado em Bayer, 2004; Czichos, 2009; Friedrich, 2012; Moore, 2013; Stachowiak, 2006; Straffelini, 2015; Wen e Huang, 2012).....	15
Figura 2-3 - Adesão de dois corpos metálicos.....	18
Figura 2-4 - Esquema representativo dos fatores que influenciam e resultam do sistema tribológico.....	19
Figura 2-5 - Efeito da velocidade de deslizamento no atrito e desgaste (Chowdhury e Khalil, 2011).	20
Figura 3-1 - Árvore de funções/métodos para o tribómetro	27
Figura 3-2 - Aquisição da velocidade de rotação. 1 - Placa PICDEM 2 PLUS 2006 com LCD (2), 3 Microcontrolador PIC16F877A, 4 - sensor indutivo	30
Figura 3-3 - Esquema representativo da configuração do tribómetro, sendo P a carga aplicada, F_N a força de reação, F_a a força de atrito e M o momento aplicado ao disco.....	31
Figura 3-4 - Esquema do tipo de configuração, bloco-disco	32
Figura 3-5 – Balança A&D HR200	32
Figura 3-6 - Estrutura inicial	33
Figura 3-7 - Segunda solução para a estrutura	34
Figura 3-8 - Solução final para a estrutura	35
Figura 3-9 - Sistema de fixação amostra, opção 1.....	35
Figura 3-10 - Sistema de fixação amostra, opção 2.....	36
Figura 3-11 - Sistema de fixação amostra, opção 3.....	36
Figura 3-12 - Sistema fixação amostra com guias de anti rotação	38
Figura 3-13 - Sistemas mecânicos de aplicação de carga. Diretamente, (a), com braço triangular (b) e com barra (c).....	38
Figura 3-14 - Sistema de aplicação de carga final com opção de com ou sem barra, (a) e (b), respectivamente.	40
Figura 4-1 - Motor trifásico SIEMENS 1,5 kW	44

Figura 4-2 - Placas de aço já existentes: base, (a), e vertical, (b).....	45
Figura 4-3 - Placa superior. Vista de cima, (a), e vista de baixo, (b).	45
Figura 4-4 - Esquema da barra com aplicação de forças, em que F_1 é a força aplicada, P_{barra} o peso da barra e F_R a força resultante exercida pela amostra.	46
Figura 4-5 - Suporte barra do sistema de aplicação de carga	47
Figura 4-6 - Esquema da força aplicada no veio de suporte da barra, (1), e respectivos diagramas (2 – tensão de corte, 3 – Momento fletor, 4 – Inclinação, 5 - Deflexão)	48
Figura 4-7 - Esquema da força aplicada no veio principal, (1), e respectivos diagramas (2 – tensão de corte, 3 – Momento fletor, 4 – Inclinação, 5 - Deflexão).....	50
Figura 4-8 – Representação das forças aplicadas e fixações da amostra, com vistas isométricas. A verde é a parte deslizante, a azul relaciona a força aplicada, a vermelho a força de atrito e a amarelo parte fixa.	52
Figura 4-9 - Gráfico deformação e tensão para as várias malhas	53
Figura 4-10 - Suporte com malha de 0,2 mm	54
Figura 4-11 - Simulação das tensões obtidas durante a realização de um teste	54
Figura 4-12 - Simulação da deformação obtida durante a realização de um teste ..	55
Figura 4-13 – Simulação do conjunto ao nível da tensão.....	56
Figura 4-14 – Simulação do conjunto ao nível da deformação	56
Figura 4-15 – Simulação com a carga máxima admissível ao nível da tensão	57
Figura 4-16 – Simulação com a carga máxima admissível ao nível da deformação	57
Figura 4-17 - Solução final para o tribómetro	58
Figura 5-1 - Placa base	63
Figura 5-2 - Suporte vertical com alojamento do rolamento.....	64
Figura 5-3 - Suporte superior com vista de cima, (a), e vista de baixo, (b).	64
Figura 5-4 - Veio de transmissão de potência e disco antagonista.....	65
Figura 5-5 - Sistema completo para a aplicação de carga.	66
Figura 5-6 - Sistema de suporte da amostra	66
Figura 5-7 - Parte mecânica do tribómetro toda desmontada.....	67
Figura 5-8 - Evolução do processo de montagem da parte mecânica	68
Figura 5-9 - Localização do sensor	69
Figura 5-10 - Tribómetro completo	69
Figura 5-11 - Pesos mortos para aplicação no tribómetro	70

Figura 6-1 - Estado dos conjuntos amostra disco depois dos testes	75
Figura 6-2 - Coeficiente de desgaste das amostras.....	76
Figura 6-3 – Processo de medição, na face de desgaste, das zonas não desgastada, a), onde L_1 e L_2 representam as larguras e C representa o comprimento total da amostra. Interseção entre amostra disco b). Volume de perda de material obtido, c).....	77
Figura 6-4 - Perda de volume real vs. perda de volume teórico.....	78

LISTA DE TABELAS

Tabela 2-1 - Coeficientes de atrito para contacto deslizante (Bayer, 2002).....	11
Tabela 2-2 - Ilustração de situações de desgaste (Adaptado Bayer, 2002)	14
Tabela 2-3 - Classificação do fenómeno de desgaste (Friedrich, 2012).....	16
Tabela 2-4 - Tipos de configurações de tribómetros (Phoenix-tribology)	24
Tabela 3-1 - Vantagens e desvantagens dos vários sistemas possíveis para aplicação de carga.....	28
Tabela 3-2 - Vantagens e desvantagens de motores elétricos (ELETROBRAS; et al., 2009; Heckler, 2012)	29
Tabela 3-3 - Comparação entre opções de sistemas de fixação de amostras	37
Tabela 3-4 - Comparação entre opções de sistemas de aplicação de carga.....	39
Tabela 4-1 - Coeficientes de atrito dinâmico entre materiais (Bayer, 2002).....	42
Tabela 4-2 - Pressupostos do projeto.....	42
Tabela 4-3 - Estudo para dois diâmetros diferentes do disco antagonista.....	43
Tabela 4-4 - Características Rolamento de rolos cilíndricos (SKF).....	51
Tabela 4-5 - Tensão máxima e Deformação máxima para diferentes malhas.....	53
Tabela 5-1 - Correspondência entre peso aplicado e força exercida na amostra.....	71
Tabela 5-2 – Cargas possíveis no tribómetro	72
Tabela 6-1 – Características dos materiais utilizados.....	73
Tabela 6-2 - Condições utilizadas nos ensaios para cada disco	74
Tabela 6-3 - Peso das amostras antes e depois dos testes e respetiva diferença.....	75

SIMBOLOS E ABREVIATURAS

ABS	Acrylonitrile butadiene styrene
AISI	American Iron and Steel Institute
Al	Alumínio
BOR	Block-on-ring
C	Carga dinâmica
C ₀	Carga estática
cm	Centímetros
COP	Cylinder-on-plate
dl	Derivação da distância
D _{min}	Diâmetro mínimo
dP	Derivação do peso
dv	Derivação do volume
E	Módulo de elasticidade
F ₁	Força aplicada
F _a	Força de atrito
F _N	Força normal
F _R	Força resultante
g	Gramma
GPa	Giga Pascal
γ _s	Coefficiente de segurança
HB	Dureza de Brinell
H _v	Dureza de Vickers
K	Coefficiente de desgaste adimensional
k	Coefficiente de desgaste
k _{abr}	Coefficiente de desgaste
kg	Quilograma
kW	Quilowatt
l	Distância de deslizamento
L	Largura
L ₁₀	Tempo de vida rolamentos
LCD	Liquid Crystal Display
m	Metros
M	Momento
M _b	Momento fletor
mm	Milímetros
MoS ₂	Bissulfureto de molibdénio
MPa	Mega Pascal

M_t	Momento torsor
N	Newton
P	Peso
P_0	Carga equivalente
P_{barra}	Peso barra
P_c	Pressão de contacto
PIC	Programmable Interface Controller
P_t	Potência
PTFE	Politetrafluoretileno
R_a	Rugosidade média
R_d	Resistência ao desgaste
R_{dr}	Resistência ao desgaste relativa
rpm	Rotações por minuto
s	Segundos
SiC	Carboneto de Silício
T	Binário
V	Volts
V_d	Velocidade de deslizamento
v	Volume
ΔP	Variação do peso
Δv	Variação do volume
°	Graus
μ	Coefficiente de atrito
μm	Micrómetros
π	Pi
ρ	Densidade
σ_0	Tensão de cedência
ν	Coefficiente de Poisson

INTRODUÇÃO

CAPÍTULO 1

INTRODUÇÃO

Atualmente é enorme a variedade de sistemas de engenharia (máquinas, veículos, etc.) fruto do desenvolvimento ao longo dos anos. Cada sistema mecânico apresenta uma função técnica que depende de processos de movimento onde a dinâmica e o comportamento dos materiais podem tornar os componentes mais robustos e viáveis no desempenho das suas tarefas. Por exemplo, processos que envolvam transmissão de força numa máquina exigem que esses componentes sejam suficientemente resistentes de modo a evitar falhas mecânicas.

A característica comum a todos os processos com movimento é a ocorrência de resistência a esse movimento, isto é, a ocorrência de atrito que provém da interação física entre corpos com movimento relativo originando uma dissipação de energia como consequência da força criada contrária ao sentido do movimento (Czichos, 2009).

As forças de atrito têm uma grande importância em todos os processos que ocorrem na Natureza, originando-se nas áreas de contacto entre dois corpos. O simples caminhar de uma pessoa é um dos vários exemplos do dia-a-dia onde a força de atrito está presente. Sem ela esse movimento seria inexecutável.

A tribologia é uma área científica que aborda as interações entre superfícies de materiais em contacto com movimento relativo e a sua importância está relacionada com o impacto e potencial para economizar energia e materiais através de redução do atrito e do desgaste (Bhushan, 2013).

Quando uma superfície se movimenta em relação a outra, estando as duas em contacto, irá ocorrer atrito e consequentemente desgaste de material. Aquele que apresentar menor tenacidade, menor dureza terá uma perda progressiva de material mais acentuada o que implica a substituição de peças e leva a um determinado prejuízo. A tribologia atua sobre isto com o intuito de diminuir os gastos relativos a falhas mecânicas.

Perante os elevados custos económicos que a indústria suporta, que dizem respeito aos fenómenos de desgaste e atrito, a procura de soluções de diminuição destes fatores relevantes é hoje alvo de estudo e análise mais aprofundada por forma a tornar esta matéria “*um mal menor*”. Sabendo que bastam dois elementos tocarem-se, ou seja, haver intersecção e movimento entre eles para que o fenómeno de atrito e desgaste se faça mostrar, a tribologia

vem estudar e aprofundar o conhecimento destes tópicos visando assim a melhoria do contacto e posterior redução de custos.

O conceito de tribologia foi definido em 1966 como a “ciência e tecnologia da interação de superfícies em movimento relativo bem como assuntos e práticas relacionadas” (Jost, H. P., 2006). Perante isto, o estudo desta ciência visa uma redução da energia e materiais através da redução do atrito e desgaste. Economizando na energia necessária de produção e na utilização de material, a parcela de custos desce significativamente, sendo também esse um dos principais objetivos do estudo destes fatores tribológicos.

O comportamento tribológico dos materiais é condicionado por uma panóplia de fatores e os seus efeitos são numerosos, pois a tribologia não só depende do atrito e desgaste mas também de outros aspetos que eventualmente influenciam o sistema tribológico. Na Figura 1-1 pode observar-se um esquema referente a esses vários fatores.



Figura 1-1 - Fatores que afetam um sistema tribológico (adaptado de J. Paulo Davim & A. Monteiro Baptista, 2013)

Por forma a analisar e compreender os fenómenos tribológicos em questão, desgaste e atrito, são frequentemente utilizados tribómetros. Através destes equipamentos é possível a caracterização tribológica de pares de materiais e obter parâmetros como o coeficiente de atrito e de desgaste, tendo para isso a necessidade de controlar variáveis de ensaio, como a carga aplicada, a velocidade de rotação e deslizamento, entre outras que se considerem importantes e que possam influenciar na interação das superfícies em contacto.

Sabendo da existência de vários tipos de tribómetros e de várias configurações possíveis no mercado, este projeto insere-se na necessidade de estudar interações do tipo bloco sobre disco, desenvolvendo um equipamento que permita a recolha de dados desse tipo de contacto através de ensaios experimentais.

De um modo geral, o projeto e construção de um tribómetro requer uma prévia análise sobre o seu emprego e o tipo de contacto que pretende estudar, visto que deverá tomar uma configuração diferente para a análise de cada tipo de contacto, tornando-se assim um mecanismo pouco abrangente e restrito para cada aplicação específica.

A presente dissertação tem como objetivo conceber um tribómetro com a configuração bloco-disco capaz de realizar ensaios em determinadas condições, que seja simples de manusear e ao mesmo tempo económico para evitar grandes investimentos no seu desenvolvimento.

Para o cumprimento destes objetivos, a dissertação encontra-se dividida em 3 partes (pesquisa, projeto e obtenção da máquina) sendo composta no total por 7 capítulos, relacionados entre eles.

No **capítulo 1** está inserida a presente introdução onde é indicado o tema a explorar, a área onde este se inclui, os objetivos a que se propõe esta dissertação e descrita a organização da mesma.

O **capítulo 2** descreve a revisão bibliográfica realizada, isto é, são analisados aspetos relevantes acerca da tribologia, quais as suas variantes e tipos de mecanismos de testes.

No **capítulo 3** é relatado as etapas do projeto do tribómetro e quais os seus requisitos e especificações. Estas considerações são bastante importantes para definir os tipos de sistemas a aplicar no equipamento, essenciais para o seu funcionamento.

O **capítulo 4** é dedicado ao dimensionamento da máquina. Neste capítulo é estudado não só os sistemas críticos de uma forma individual, como também toda a parte mecânica com todos os sistemas ligados entre si.

O **capítulo 5** apresenta fisicamente o tribómetro. É explicado a obtenção dos componentes da máquina e a sua montagem.

O **capítulo 6** destina-se ao teste do tribómetro obtido. São realizados ensaios e, posteriormente, feita a análise dos resultados.

No **capítulo 7** encontra-se as principais conclusões de todo o desenvolvimento da dissertação, indicando ainda algumas perspectivas futuras para trabalhos a realizar nesta área.

O presente documento é finalizado com a apresentação das referências bibliográficas utilizadas e com os anexos elaborados.

PARTE I
REVISÃO
BIBLIOGRÁFICA

CAPÍTULO 2

SISTEMAS TRIBOLÓGICOS

A tribologia é uma área científica que aborda as interações entre superfícies de materiais em contacto com movimento relativo e a sua importância está relacionada com o impacto e potencial para economizar energia e materiais (Bhushan, 2013). O termo foi introduzido pela primeira vez por Jost em 1966 num relatório publicado na Grã-Bretanha pelo Departamento de Ciência (JOST, 2006).

A característica comum a todos os processos com movimento é a ocorrência de resistência a esse mesmo movimento que provém da interação física entre corpos ou objetos originando uma dissipação de energia como consequência da força criada contrária ao seu sentido, designada por Força de Atrito (Czichos, 2009).

A população já vem empregando soluções práticas relacionadas com a tribologia há muito tempo, embora o termo seja relativamente recente. A invenção da roda mostra claramente o interesse em reduzir o atrito durante o movimento.

Lida-se com factos relativos a esta área no quotidiano, por exemplo a prática de desporto ou até mesmo o simples gesto de caminhar.

As forças de atrito têm uma grande importância em todos os processos que ocorrem na Natureza (Stachowiak e Batchelor, 2013). Em alguns casos o seu aumento é conveniente ao processo, porém noutros a sua ausência seria o ideal.

No ambiente industrial o controlo do atrito é fundamental pois é o principal fator que origina desgaste resultando num desperdício de material e perda de eficiência (Olea-Mejia, Brostow e Buchman, 2010). Os custos relativos a falhas mecânicas é então aumentado devido à dissipação de energia provocada por esses fatores.

Na indústria automóvel o grande desafio é a redução do consumo de combustível o que pode ser conseguido reduzindo a energia dissipada através do atrito. Segundo Halling (1975) um veículo possui mais de 2000 pontos de contacto tribológico o que sugere um elevado grau de dissipação de energia. Grande parte da energia retirada do processo de combustão é então perdida, daí o processo de redução do consumo de combustível passar pela diminuição da fricção para obter maior aproveitamento da potência retirada da queima para fazer movimentar o veículo.

O desgaste e o atrito são a consequência de um dado sistema tribológico e não propriedades de um material. Para descrever um sistema tribológico é necessário utilizar elementos imprescindíveis no estudo do comportamento ao desgaste e ao atrito de um dado par de materiais (Bayer, 2002).

2.1 Atrito

Atrito é a resistência ao movimento que existe quando um objeto sólido é movido tangencialmente em relação a uma superfície de contacto, ou quando uma tentativa de produzir tal movimento é feita. É expresso em termos quantitativos como uma força, a qual é proporcional à carga normal existente entre corpos (Rabinowicz, 1995). De acordo com Halliday et al (2006), a partir da relação entre a força de atrito e a força normal, surge uma grandeza adimensional conhecida como coeficiente de atrito que se divide em estático e dinâmico. O coeficiente de atrito estático é determinado no instante de iminência do movimento relativo entre as superfícies em contacto enquanto o coeficiente de atrito dinâmico ocorre no instante em que há movimento relativo entre as superfícies.

O atrito também pode ser visto do ponto de vista energético. É um processo onde a energia cinética é convertida em outras formas de energia, como térmica, mecânica elétrica e acústica. O balanço de energia dissipada dependerá da natureza dos corpos em contacto (Stachowiak e Batchelor, 2013). Estando dois objetos em contacto, o atrito manifesta-se em dois aspetos. Um é a força necessária que o sistema requer para iniciar ou manter o movimento. O outro, é a energia dissipada durante o movimento relativo. Embora o atrito e o desgaste sejam fenómenos distintos, eles estão relacionados um com o outro. O desgaste requer aplicação de força e consumo de energia uma vez que os mecanismos de desgaste são afetados pelo corte resultante da carga e pelo aumento da temperatura proveniente do aquecimento na interação. Ou seja, ambos os aspetos do atrito podem influenciar o comportamento do desgaste. Em contrapartida, o comportamento do atrito pode ser influenciado pelas mudanças da superfície causadas pelo desgaste. Estes fenómenos são complexos e não se tem um conhecimento preciso sobre o papel de cada variável do tribosistema sobre os mesmos, o que torna relativamente complicado o desenvolvimento de um modelo matemático capaz de englobar todos os fenómenos de atrito e desgaste. Por esse motivo modelos existentes se limitam a descrever um dado comportamento de um determinado material para condições bem específicas de aplicação (Eriksson, Bergman e Jacobson, 2002).

Segundo Al-Bender e Swevers (2008), o regime de deslizamento é caracterizado por um contínuo processo de formação e quebra dos pontos de contato tal que a força de atrito torna-se predominantemente uma função da velocidade de escorregamento relativa entre os corpos. Conforme a literatura (Al-Bender e Swevers, 2008; Bayer, 2002), os mecanismos

físicos que explicam a força de atrito quando uma superfície desliza relativamente sobre a outra são os seguintes:

- Adesão – envolve a partilha de junções formadas entre duas superfícies em contacto.
- Deformação – envolve o deslocamento de material como um corpo movido através de outro.
- Histerese – envolve o atraso na resposta exibida pelo corpo ao reagir a mudanças nas forças que atuam sobre ele. Este tipo de mecanismo é apenas significativo com materiais viscoelásticos, como por exemplo a borracha.

O coeficiente de atrito, que é usado para caracterizar o mecanismo ao nível do atrito, é obtido através do quociente entre a força de atrito, F_a , e a força normal, F_N .

$$\mu = \frac{F_a}{F_N} \quad (2.1)$$

Enquanto que a gama de coeficiente de atrito se estende ao longo de várias ordens de grandeza, é significativamente menor do que o intervalo associado a taxas de desgaste normalizadas ou coeficientes de desgaste (Bayer, 2002). Na Tabela 2-1 pode observar-se os coeficientes de atrito em contacto deslizante, com ou sem lubrificação, para diferentes pares de materiais.

Tabela 2-1 - Coeficientes de atrito para contacto deslizante (Bayer, 2002).

Pares de materiais	Não lubrificado	Lubrificado
Aço – Aço	0,7 – 0,8	0,1 – 0,3
Aço – Aço Inox	0,7 – 1,2	0,1 – 0,3
Aço – Ligas de Níquel	0,7 – 1,3	0,1 – 0,3
Aço – Ligas de Cobre	0,7 – 1,2	≈0,15
Aço – Ligas de Alumínio	0,8 – 1,4	0,1 – 0,3
Aço Inox – Aço Inox	0,9 – 1,5	0,1 – 0,2
Acetal – Aço	≈0,35	0,15
PTFE com acetal – Aço	0,2 – 0,3	–
Nylon – Aço	0,4 – 0,6	0,15 – 0,25
Grafite com nylon – Aço	≈0,6	≈0,25
MoS ₂ com nylon – Aço	≈0,6	≈0,25
PTFE com nylon – Aço	0,1 – 0,2	–
PTFE – Aço	0,09 – 0,12	–

Poliuretano – Aço	1 – 1,5	0,5 – 1
Borracha – Aço	3 – 10	2 – 4
Cerâmico – Cerâmico	0,3 – 0,8	0,1 – 0,3
Cerâmico – Metal	0,2 – 0,8	0,1 – 0,3
Placa de cromo – Metal	0,2 – 0,4	0,1 – 0,3
Placa de níquel – Metal	0,2 – 0,4	0,1 – 0,3
Revestimento titânio – Metal	0,1 – 0,5	0,1 – 0,3

De notar que, salvo raras exceções, os coeficientes de atrito para deslizamentos a seco ronda os 0,1 a 2 e para deslizamentos com lubrificação ronda os 0,1 a 0,4. Em sistemas mecânicos é importante ter em conta estes valores, pois serão necessários para perceber o comportamento que o sistema poderá ter ou identificar a melhor solução para um determinado equipamento.

2.2 Desgaste

Entre órgãos de máquinas existem interações de contacto entre corpos sólidos que envolvem fenómenos complexos onde o atrito (no duplo sentido, resistência ao movimento e dissipação de energia) e o desgaste são as manifestações mais facilmente observáveis, como já se viu anteriormente.

Ao longo dos anos a definição do desgaste tem sido reconhecida como a perda de material duma superfície, a transferência de material de uma superfície para outra ou o movimento de material dentro da mesma superfície. Stachowiak (2006) define-o como sendo *“a perda progressiva de substância da superfície de um corpo que ocorre como resultado do movimento relativo com outra superfície”*.

Alguns dos primeiros estudos relativos ao comportamento de desgaste de materiais foram concebidos pelo grande génio Leonardo da Vinci. Nos seus estudos descreveu o desgaste e deu um passo muito importante neste capítulo ao desenvolver os rolamentos por forma a minimizá-lo (Czichos, 2009).

Em cada situação onde ocorre desgaste há a necessidade de avaliar o processo e encontrar a solução mais adequada para cada caso. Segundo Bayer (2002) a análise do desgaste é um método de engenharia, demonstrado na Figura 2-1, usado para resolver problemas de desgaste que surjam tanto em equipamentos como preocupações com novos projetos.

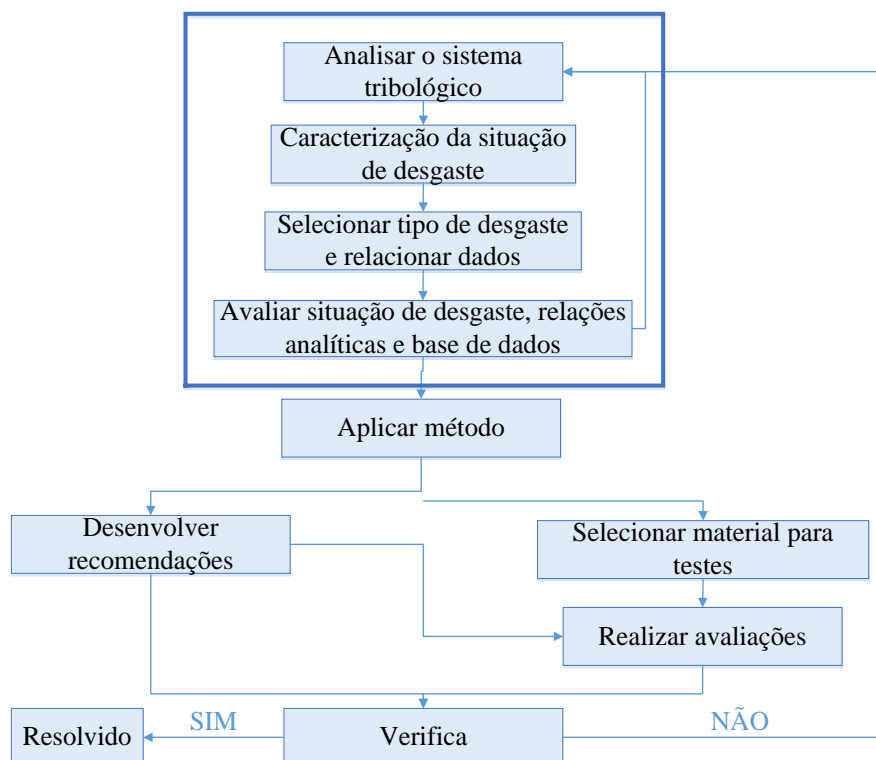


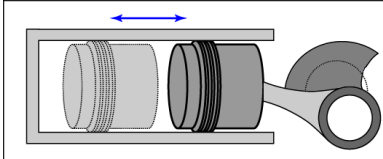
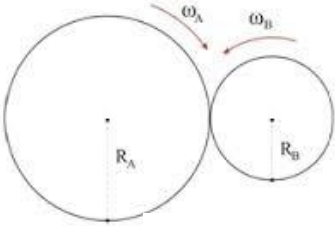
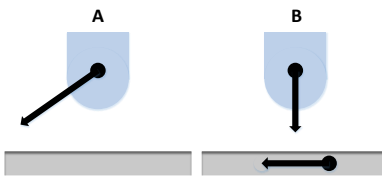
Figura 2-1 - Esquema ilustrativo das etapas envolvidas na análise de desgaste (Adaptado de Bayer, 2002)

Para melhor compreender a figura anterior, genericamente, identifica-se o problema fazendo uma verificação da situação com o intuito de retirar informações ao nível dos componentes, condições de contacto, ambiente e, em seguida, caracteriza-se o tipo de movimento em causa, geometria do contacto, forças envolvidas e descrição dos materiais entre outros fatores. Reunindo toda a informação prossegue-se para a avaliação e modulação do programa, ou seja, pode-se usar relações matemáticas para descrever o desgaste ou simular o processo recorrendo a um dispositivo capaz de reproduzir a situação com os mesmos parâmetros. No presente documento, a máquina concebida não é para casos específicos mas pode ser utilizada de uma maneira geral para processos ao nível do desgaste por deslizamento.

2.2.1 Tipos e mecanismos de desgaste

Existe três grandes situações relacionadas com a natureza do movimento durante o contacto. São elas *sliding*, *rolling* e o impacto e estão caracterizadas na Tabela 2-2.

Tabela 2-2 - Ilustração de situações de desgaste (Adaptado Bayer, 2002)

<i>Sliding</i>	<i>Rolling</i>	<i>Impacto</i>
		
Movimento caracterizado pela distância de deslizamento que ocorre tangencialmente à superfície. Em geral, todos os mecanismos de desgaste resultantes deste tipo de movimento apresentam um maior potencial de desgaste e por isso é a situação mais severa.	Consiste na rotação das superfícies em contacto e o seu comportamento é caracterizado, normalmente, pelo número de revoluções antes de atingir um estado inaceitável de desgaste. É um movimento mais suave e um exemplo característico dos rolamentos.	Implica uma colisão entre superfícies e está associado à deformação dos materiais que compõem os mecanismos. Cada material possui uma tensão elástica e, no caso de ser ultrapassada, origina um desgaste bastante severo.

Existem vários mecanismos de desgaste e, geralmente, cada um está associado a uma ou mais causas. A Figura 2-2 ilustra os cinco principais e exemplifica a proveniência e o desenvolvimento de cada um.

O aspeto da superfície desgastada é um dos elementos fundamentais na identificação do tipo de mecanismo responsável por cada situação concreta.

Conforme alguns autores (Bayer, 2004; Czichos, 2009; Friedrich, 2012; Moore, 2013; Stachowiak, 2006; Straffelini, 2015; Wen e Huang, 2012), e partindo da análise da Figura 2-2, enquanto a abrasão provoca estrias mais ou menos profundas na direção do deslizamento, a adesão caracteriza-se principalmente pelo aparecimento de material transferido de um corpo para o outro. Por outro lado, na erosão a formação de crateras é típica, porém, se o ângulo de incidência for demasiado pequeno, o processo assemelha-se ao da abrasão onde as crateras alongam-se e ganham a forma de ranhuras.

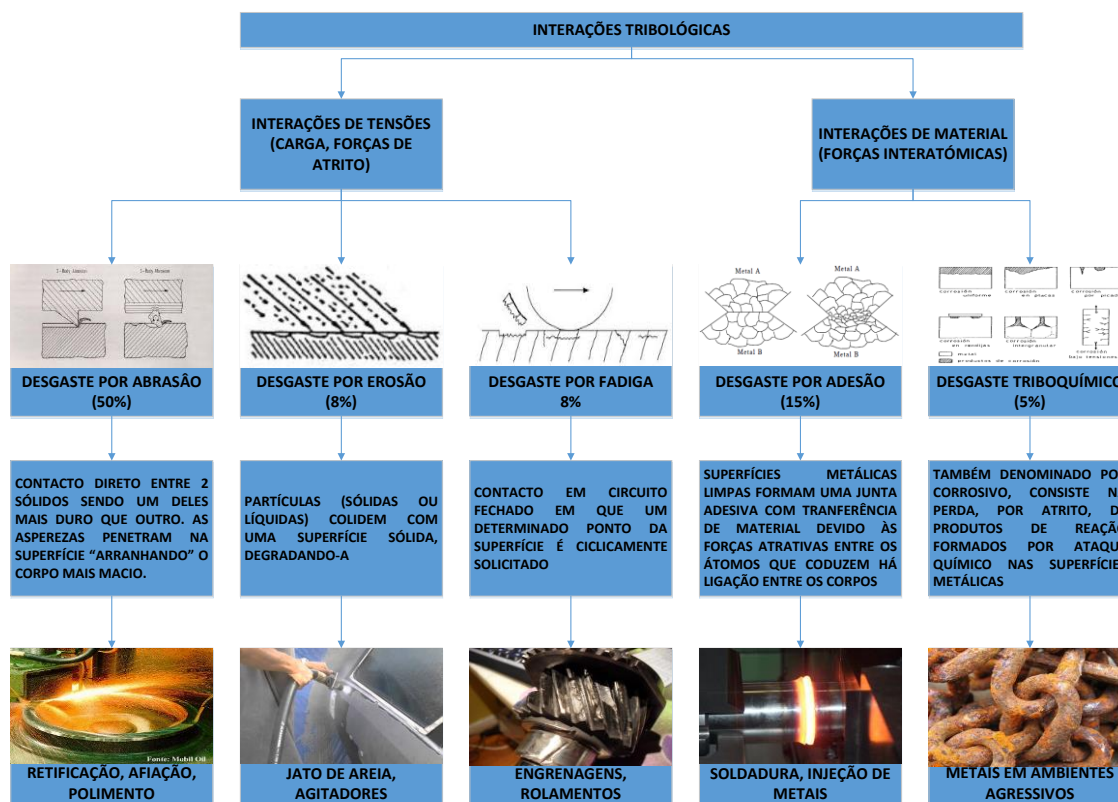


Figura 2-2 - Interações tribológicas e mecanismos de desgaste (Baseado em Bayer, 2004; Czichos, 2009; Friedrich, 2012; Moore, 2013; Stachowiak, 2006; Straffelini, 2015; Wen e Huang, 2012)











Ainda com base nestes autores, se o mecanismo dominante for a fadiga, encontram-se fendas que acabam por abrir à superfície e cavidades onde se pode observar no fundo as características estrias de fadiga correspondentes à fase de propagação da fenda. Por sua vez, se o domínio pertencer aos processos triboquímicos (ou corrosão) promove-se o aparecimento de produtos na superfície resultantes da reação de materiais.





Contudo, existe outros mecanismos que originam desgaste mas têm outras formas de se exprimir. A cavitação é um deles e é um fenómeno originado por quedas repentinas de pressão, geralmente observados em sistemas hidráulicos. A combinação entre pressão, temperatura e velocidade resulta na liberação de ondas de choque e micro-jatos energéticos causando a aparição de tensões mecânicas o que provoca danos na superfície atingida (Brennen, 2013).

Outro tipo de mecanismo diferente dos que já se viu mas que pode ser relacionado com alguns é o *fretting*. É um fenómeno de desgaste em contactos com movimento oscilante de pequena amplitude. O movimento cíclico entre as duas superfícies pode originar trepidação como é o caso do transporte de máquinas cujos órgãos não foram convenientemente imobilizados. Normalmente é uma manifestação de desgaste por adesão, embora possa apresentar também aspetos de desgaste abrasivo ou até mesmo corrosivo.

Para uma melhor percepção do desgaste a Tabela 2-3 ajuda a compreender o comportamento deste fenómeno e, de certa forma, resume o mencionado anteriormente em relação a este tema.

Tabela 2-3 - Classificação do fenómeno de desgaste (Friedrich, 2012)

Estrutura do sistema	Ação tribológica (representação)	Tipo de desgaste	Mecanismo efetivo (individual ou combinado)			
			Adesão	Abrasão	Fadiga	Reações tribológicas
Sólido - pouca interface (separação através de um filme de fluido) - sólido	Deslizamento Rolamento Impacto 				X	X
Sólido - sólido (contacto, atrito, lubrificação)	Deslizamento 	Desgaste por deslizamento	X	X	X	X
	Rolamento 	Desgaste por rolamento	X	X	X	X
	Impacto 	Desgaste por impacto	X	X	X	X
	Oscilação 	<i>Fretting</i>	X	X	X	X
Sólido - sólido e partículas	Deslizamento 	Desgaste abrasivo		X		
	Deslizamento 	Desgaste abrasivo a três corpos		X		
	Rolamento 	Desgaste abrasivo a três corpos		X		
Sólido - fluido com partículas	Fluxo 	Desgaste erosivo		X	X	X
Sólido	Fluxo 	Desgaste erosivo		X	X	X

- gás com partículas	Impacto		Desgaste por impacto de partículas	X	X	X
						
Sólido - fluído	Fluxo de oscilação		Cavitação, erosão		X	X
	Impacto		Erosão		X	X

2.2.2 Coeficiente e taxa de desgaste

Para quantificar o coeficiente de desgaste são utilizados modelos físicos que dependem do tipo de mecanismo e forma em causa, porém, o presente documento, focar-se-á nos coeficientes relativos ao desgaste por abrasão e adesão relacionados com o movimento linear de deslizamento (*sliding*) visto que estão relacionados com o tema.

Segundo Davim e Baptista (2013), existe três grandezas para caracterizar o desgaste por abrasão:

- Volume desgastado – V, dado ao fim de um certo tempo, ou uma certa distância ou ainda de um certo comprimento;
- Resistência ao desgaste – R_d , dada como o inverso do volume desgastado ($R_d=1/V$);
- Resistência relativa – R_{dr} , dada como o quociente entre a resistência ao desgaste do material em estudo e um material padrão ($R_{dr}=R_{d(material)}/R_{d(pad\tilde{r}ao)}$).

A taxa de desgaste (dv/dl) e o volume desgastado exprimem-se pelas seguintes relações, equação 2.2 e 2.3, atualmente aceites pela grande parte dos especialistas:

$$\frac{dv}{dl} = k_{abr} \frac{F_N}{H_v} \quad (2.2)$$

$$v = k_{abr} \cdot F_N \cdot l / H_v \quad (2.3)$$

Sendo, N a força normal aplicada (carga), H_v a dureza da superfície mais macia, l o comprimento de escorregamento e K_{abr} o coeficiente de abrasão que depende de alguns fatores, tais como, geometria e natureza dos grãos ou das rugosidades.

Contudo, na adesão o método é bem diferente, já que o fenómeno é bem diferente da abrasão. Segundo Borruto e Taraschi (1995) as junções no processo de adesão ocorrem numa região deformada plasticamente e contaminada tendo por isso propriedades diferentes. Se a resistência da junção for inferior à dos metais em estudo a rutura dá-se na junção (desgaste

suave). Por outro lado se a resistência da junção for maior do que a dos materiais então a rutura ocorrerá no metal menos resistente (desgaste severo) (Davim e Baptista, 2013).

Na Figura 2-3 pode-se observar a adesão entre dois materiais metálicos.

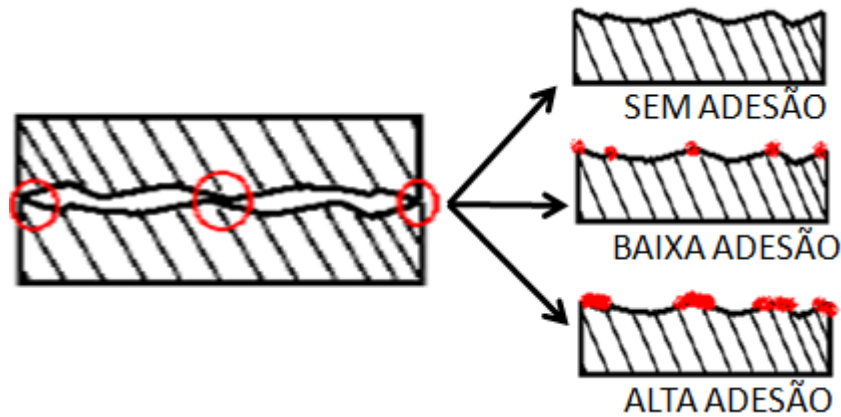


Figura 2-3 - Adesão de dois corpos metálicos

A taxa de desgaste para este tipo de mecanismo, segundo Bayer (2002) é dada por:

$$\frac{dv}{dl} = \frac{kF_N}{3H_v} \quad (2.4)$$

Por vezes, muitos especialistas relacionam a taxa de volume desgastado com a perda de peso que, no fundo, é bastante mais prática e ajuda a uma melhor perceção do estudo. Conhecendo a densidade do material a ensaiar:

$$\rho = \frac{P}{v} \quad (2.5)$$

Sendo v o volume e P o peso, tem-se:

$$\frac{dv}{dl} = \frac{1}{\rho} \frac{dP}{dl} \quad (2.6)$$

Então pesando a amostra antes da realização do ensaio e no fim obtém-se:

$$\Delta v = \frac{\Delta P}{\rho} \quad (2.7)$$

Relacionando a equação 2.7 com a 2.2 (no caso de desgaste abrasivo) ou com a 2.4 (no caso de desgaste adesivo) facilmente se consegue obter o coeficiente de desgaste. Na equação 2.8 é retirada a variável da dureza para conseguir analisar o desgaste independentemente do seu tipo.

$$\Delta P = \rho k F_N l \quad (2.8)$$

2.3 Parâmetros que influenciam o comportamento tribológico de materiais

Quando ocorrer qualquer tipo de alteração em fatores de entrada, *inputs*, num sistema tribológico, o comportamento de um dado par de materiais é, por sua vez, afetado originando, conseqüentemente, outras alterações em fatores de saída, *outputs*. Por exemplo, a taxa de desgaste de um determinado material é bastante influenciado por fatores como a carga, velocidade de deslizamento, temperatura (Li e Cai, 2011), as propriedades do material e a presença de lubrificação (Benabdallah, 2007).

Na Figura 2-4 apresenta-se um resumo dos parâmetros que influenciam o comportamento tribológico de materiais. Mais a frente, cada um é aprofundado para melhor entender o seu envolvimento com o sistema tribológico.

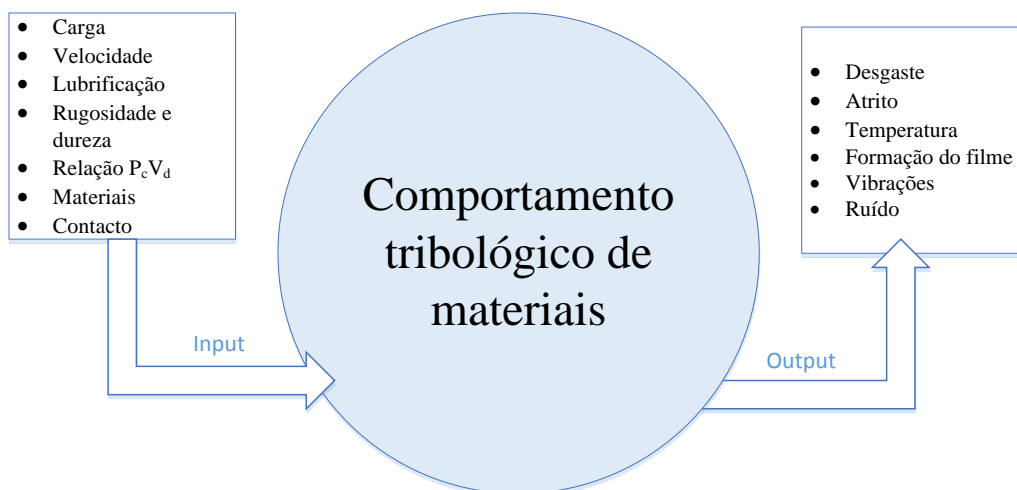


Figura 2-4 - Esquema representativo dos fatores que influenciam e resultam do sistema tribológico

2.3.1 Rugosidade e Dureza

A rugosidade e a dureza são parâmetros complexos no comportamento tribológico dos materiais. Segundo Kubiak, Liskiewicz e Mathia (2011) a rugosidade tem influência significativa sobre o atrito e o desgaste. Para rugosidades altas a taxa de desgaste é maior do que para rugosidades mais baixas. Pelo contrário, o coeficiente de atrito para rugosidades mais baixas é maior do que para rugosidades mais altas (Sedlaček, Podgornik e Vižintin, 2009).

No estudo do comportamento ao desgaste, a dureza reflete-se nos resultados dos testes. Borruto e Taraschi (1995) quando testaram duas amostras do aço AISI 9840 submetidas a tratamentos distintos concluíram que, para o mesmo tipo de material, quanto maior a dureza menor a perda de peso. No entanto, para materiais diferentes isso não se verifica o que torna a dureza um parâmetro complexo.

2.3.2 Velocidade de deslizamento

A velocidade de deslizamento tem bastante influência no comportamento tribológico de materiais nomeadamente ao nível do desgaste e atrito (Amiriyani *et al.*, 2015). Porém o aumento da velocidade de deslizamento não implica obrigatoriamente um aumento do desgaste, uma vez que depende do sistema tribológico. Franklin (2001) realizou ensaios com polímeros e verificou que a velocidade tanto pode aumentar como diminuir o fator desgaste para diferentes materiais. De outra perspetiva, Chowdhury e Khalil (2011) efetuaram ensaios a seco num tribómetro *pin-on-disc* utilizando pinos de aço inoxidável contra disco de alumínio e obtiveram os resultados desmonstrados na Figura 2-5.

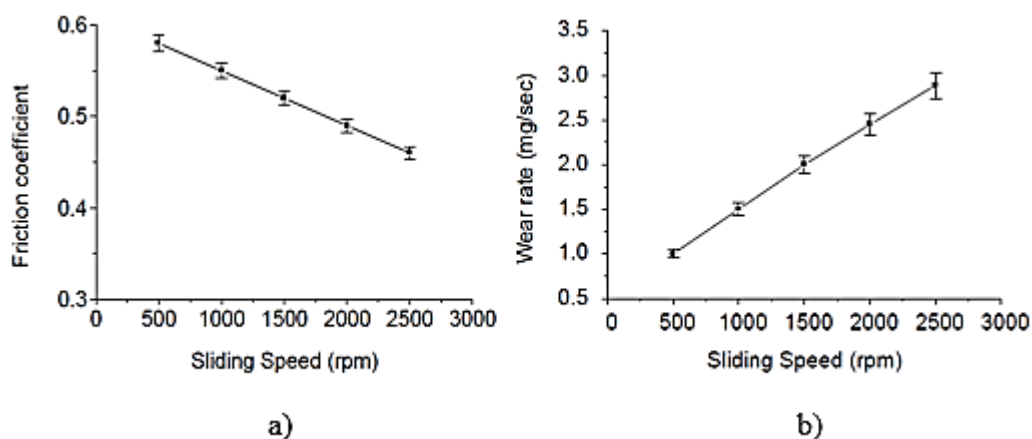


Figura 2-5 - Efeito da velocidade de deslizamento no atrito e desgaste (Chowdhury e Khalil, 2011).

Os autores desta investigação concluíram então, que o aumento da velocidade de deslizamento induz num aumento do desgaste e, em contrapartida, uma diminuição do coeficiente de atrito.

2.3.3 Carga

Em todos os mecanismos de contacto com movimento relativo entre componentes a presença de atrito e desgaste é evidente.

A carga aplicada é outro parâmetro que afeta o funcionamento do mecanismo. Um aumento de carga pode ter como consequência um maior desgaste e coeficiente de atrito, por exemplo num contacto aço-alumínio (Jiménez *et al.*, 2006). Por outro lado, entre polímeros esse aumento pode levar à diminuição do coeficiente de atrito sendo favorável em algumas ocasiões (Chaudri, Suvanto e Pakkanen, 2015). Zhou *et al* (2008) testaram num contacto *ball-on-disk*, bolas de nitrato de silício e disco do mesmo material mas com revestimento amorfo e concluíram que a velocidade de deslizamento tem maior influencia evidente do que a carga aplicada no coeficiente de atrito e na taxa de desgaste. Denape e Lamon (1990), utilizando um contacto *roller-on-beam*, testaram materiais cerâmicos e averiguaram que o aumento de carga não interfere no coeficiente de atrito e, em contrapartida, aumenta o desgaste variando consoante o tipo de cerâmica.

Com isto, verifica-se que a alteração da intensidade da carga pode originar variados resultados dependendo dos tipos de materiais utilizados e condições impostas.

2.3.4 Temperatura

A temperatura depende das condições de ensaio e do calor gerado por atrito na interface. O aumento da temperatura é resultado da dissipação de energia por atrito na zona de contacto (Samyn *et al.*, 2007 a).

De acordo com Chang *et al* (2006) a temperatura e o atrito estão interligados e consideram o seu comportamento idêntico ao longo do ensaio. Os autores afirmam ainda que o aumento da temperatura na zona de contacto está relacionado com o aumento do atrito, sendo mais acentuado no estado inicial de desgaste. Isto é explicado devido ao aquecimento proveniente da fricção entre os corpos aumentando a área de contacto, neste caso das poliamidas.

As temperaturas produzidas em interfaces deslizantes são também sensíveis à geometria. Vick e Furey (2001) demonstraram que, utilizando uma configuração com múltiplos contactos, o aumento da temperatura diminui à medida que o número de contactos aumenta assim como o espaçamento entre eles.

2.3.5 Lubrificação

A lubrificação consiste na adição de um material com o intuito de reduzir o atrito e desgaste entre as superfícies em contacto, porém o seu efeito depende do sistema tribológico. O lubrificante pode ser seco, pastoso ou líquido. No caso da lubrificação a seco, esta é realizada por sólidos, por exemplo grafite, PTFE, e do MoS₂ (bissulfureto de molibdénio), pela adição de partículas ou mantas de diversos tipos (Bayer, 2002).

A lubrificação atua como um filme que separa as duas superfícies sem causar qualquer dano. Com isto, apesar da dependência de outras variáveis, a redução do atrito é evidente e consequentemente a taxa de desgaste. Cada fluido depende das suas características para ser ou não o indicado como lubrificante de um dado mecanismo. Uma das mais importantes é sua viscosidade que, avaliando os requisitos do sistema mecânico em causa, seleciona o lubrificante mais adequado (Czichos, 2009).

2.3.6 Formação do filme

A formação do filme, também designado por terceiro corpo, foi introduzida por Godet em 1970 com o objetivo de identificar a interface entre dois sólidos postos em contacto. Pode ser injetado artificialmente, como é o caso dos óleos e outros tipos de lubrificantes, ou pode ser o resultado do arrancamento de material no caso de superfícies secas (Fillot, Iordanoff e Berthier, 2007).

De acordo com Samyn et al (2007 a), a formação do filme depende da adesão, do calor gerado pelo atrito e da compactação das partículas no local de escorregamento. É o produto de uma complexa interação mecânica e química, que pode variar no tempo com o tipo de material e ainda de acordo com as condições de velocidade, temperatura e pressão impostas (Hee e Filip, 2005). Além disso, a rugosidade dos materiais também desempenha um papel importante nas características do filme (Langlade, Fayeulle e Olier, 1994). Daí a grande dificuldade em prever o desempenho e comportamento do atrito de um material.

Um filme contínuo e uniforme pode aumentar a resistência ao desgaste e diminuir o coeficiente de atrito (Yu, Hu e Yin, 2008). Contudo, se a carga aplicada e a pressão são baixas, assim como o calor gerado entre as superfícies, num escorregamento a seco, pode dificultar a formação do filme. A implementação da correta carga que, por sua vez, leva à correta pressão, é um aspeto importante pois favorece a ocorrência de reações triboquímicas propícias à formação do filme (Chen *et al.*, 2005). Porém, Liu et al (2002) comprovou que a película inicial não é constante o que faz aumentar o coeficiente de atrito. Aumentando a carga para valores superiores ao inicial, aumenta-se o calor gerado e a deposição de partículas no material antagonista é maior o que ajuda a que o filme seja formado por completo imprimindo uma diminuição no coeficiente de atrito (Yu, Hu e Yin, 2008).

2.4 Tribômetros

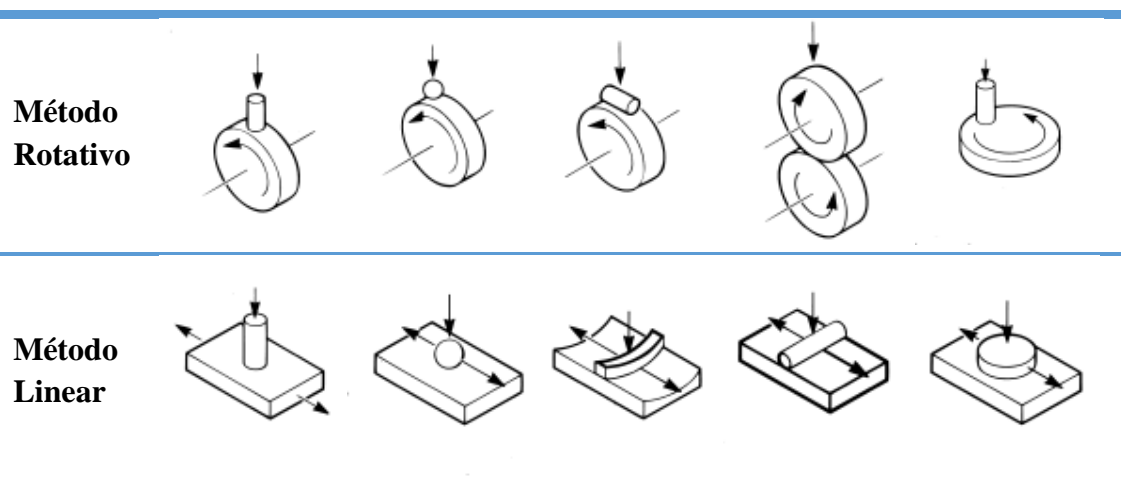
O projeto de sistemas tribológicos é complexo pois exige controlo de várias variáveis. Cada projeto necessita de teste específicos para determinar o desempenho ao atrito e ao desgaste de um dado par de materiais uma vez que, os valores de referência são meramente indicativos à exceção para condições particulares onde se podem considerar válidos. Samyn et al (2007 a) comprovam o referido quando ensaiaram diversos polímeros em dois tribômetros diferentes, no *block-on-ring* (BOR) e no *cylinder-on-plate* (COP) e, para as mesmas condições de ensaio, obtiveram resultados distintos. Portanto, os resultados dependem de todo o quadro tribológico e é indispensável que as condições ambientais sejam o mais próximo possível do ambiente para o qual o par de materiais irá ser solicitado. De notar que as propriedades, tanto físicas como mecânicas, de alguns materiais podem variar ao longo de cada ensaio e, por isso, é necessário ter em consideração na análise dos resultados a variação dessas propriedades (Samyn *et al.*, 2007 b).

O desenvolvimento de um tribómetro requer uma análise geral *a priori* do que se pretende obter e ter em conta as condições a que estará sujeito. O conhecimento dos parâmetros que influenciam (velocidade, vibrações cargas, etc) a máquina e a sua relevância é indispensável. São inúmeras as variáveis que afetam, direta ou indiretamente, os ensaios e por isso, quanto maior for o controlo dessas variáveis maior é a perceção relativamente à progressão do teste a realizar e mais fiabilidade se obtém aquando dos resultados relativos ao atrito e desgaste.

Um tribómetro é um instrumento que serve para determinar, principalmente, coeficientes de atrito, força de atrito e desgaste de superfícies em contacto. Este tipo de dispositivo foi inventado no séc. XVIII por um cientista holandês que tinha o nome de Musschenbroek (CUADRADO, 2002). Este dispositivo é composto por duas peças em contacto às quais se aplica movimento a uma ou às duas, para que se possa estudar o desgaste, forças aplicadas e coeficientes de atrito, permitindo assim caracterizar tribologicamente pares de materiais.

São vários os tribômetros que existem no mercado com determinadas configurações e cada um é, normalmente, específico para cada situação. Estas máquinas são mecanismos pouco abrangentes pois são projetados para estudar determinadas situações industriais e por isso para cada singular existe uma área restrita de aplicações.

Na Tabela 2-4 pode-se observar alguns exemplos de configurações possíveis que se pode encontrar num tribómetro sendo que todas derivam de dois grandes grupos: Método Linear e Método rotativo.

Tabela 2-4 - Tipos de configurações de tribómetros (Phoenix-tribology¹)

Como já foi referido, apesar de cada tribómetro ser único, todos eles exigem controlo de vários parâmetros não só para garantir as condições que se pretende ao longo do ensaio mas também averiguar a veracidade dos resultados obtidos.

2.5 Síntese

Ao longo deste capítulo a tribologia foi descrita como sendo uma área científica que envolve variáveis por vezes difíceis de controlar.

Para se conseguir avaliar tribologicamente materiais é necessário controlar todo o meio, a sua envolvente e as características impostas durante o estudo. Perante isto, muitas das vezes são utilizados tribómetros que permitem avaliar sobretudo o atrito e o desgaste de pares de materiais. Porém estes necessitam de um adequado projeto e rigor na sua utilização. Quanto maior for a delicadeza na preparação e execução dos ensaios, mais rigor se obtém na obtenção dos resultados.

Existem tribómetros meramente dedicados para uma função bem definida. Porém, neste caso, o objetivo é projetar e fabricar uma máquina com uma configuração bloco-disco, que é uma configuração geral que permite avaliação de pares de materiais através de um determinado contacto que varia ao longo do ensaio.

¹ <http://www.phoenix-tribology.com>

PARTE II

PROJETO

CAPÍTULO 3

ETAPAS DO PROJETO

Na elaboração de um projeto é extremamente importante definir precisamente a função que o dispositivo deverá ser capaz de executar, por forma a clarificar e definir a orientação que as tarefas de trabalho devem seguir.

Cada dispositivo é realizado para exercer determinada função e, para isso, terá vários sistemas, também dedicados a certas funcionalidades, que permitirão o bom funcionamento da máquina.

Na Figura 3-1 apresenta-se o diagrama deste projeto onde se pode identificar os vários sistemas com as várias soluções que o tribómetro poderá ter assim como a função de cada um.

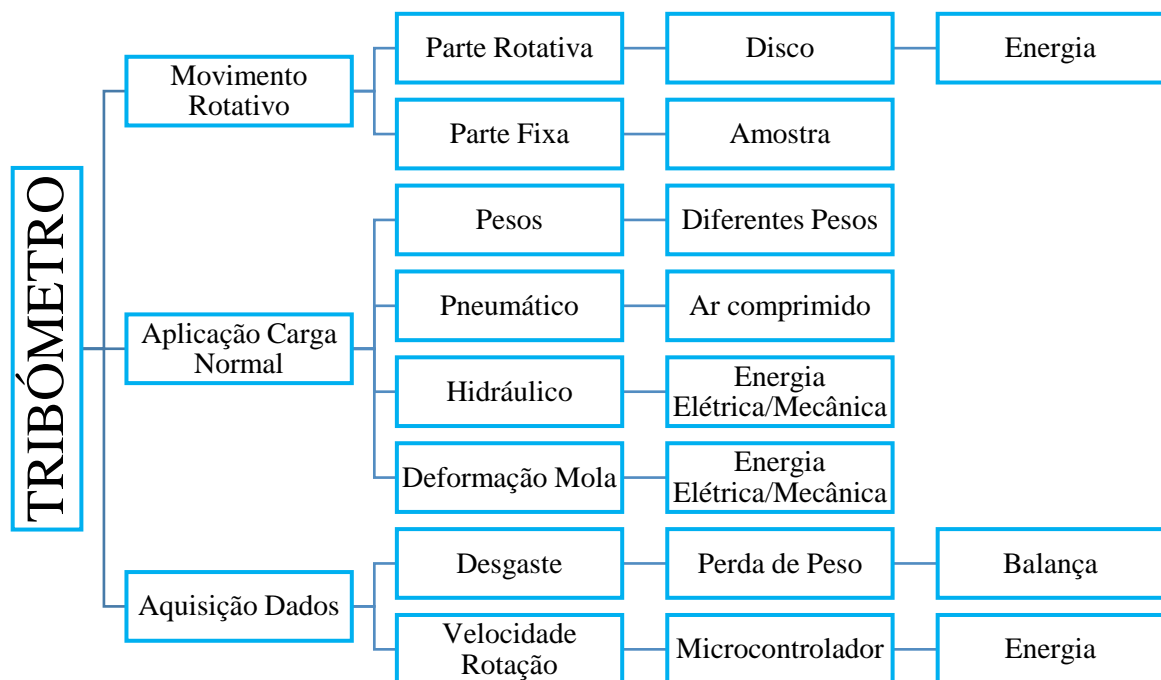


Figura 3-1 - Árvore de funções/métodos para o tribómetro

3.1 Especificações e métodos

Logo à partida, apresentou-se os requisitos/especificações iniciais em relação ao tribómetro em causa, com o intuito de definir determinados sistemas para cada tipo de função. Neste caso, abordando a máquina em si, o objetivo era averiguar o tipo de amostras a utilizar, o sistema de aplicação de carga, gama de velocidades e o processo de obtenção da taxa de desgaste.

3.1.1 Carga aplicada

Para se obter uma força de atrito é necessário aplicar uma carga normal, como visto no capítulo anterior. Sabendo que o tribómetro tinha como objetivo cargas baixas e variáveis, procedeu-se a uma análise de formas e tecnologias de aplicação de carga, representada na Tabela 3-1, para assim averiguar a melhor proposta.

Tabela 3-1 - Vantagens e desvantagens dos vários sistemas possíveis para aplicação de carga

Pneumático	Hidráulico	Pesos Mortos	Deformação Mola
Vantagens <ul style="list-style-type: none"> • Robustez dos componentes • Boa fiabilidade • Fluido não poluente • Fácil manutenção 	Vantagens <ul style="list-style-type: none"> • Permite elevadas forças • Robusto • Boa fiabilidade • Boa estabilidade • Boa precisão 	Vantagens <ul style="list-style-type: none"> • Baixo custo • Simplicidade do sistema • Compacto 	Vantagens <ul style="list-style-type: none"> • Médio custo • Boa precisão • Boa estabilidade • Sistema compacto
Desvantagens <ul style="list-style-type: none"> • Necessidade de estação de ar comprimido • Difícil trabalhar com velocidades baixas 	Desvantagens <ul style="list-style-type: none"> • Elevado custo de implementação • Fluido poluente e inflamável • Manutenção dispendiosa • Necessidade de bastante espaço 	Desvantagens <ul style="list-style-type: none"> • Falta de precisão • Erro humano devido à manipulação manual 	Desvantagens <ul style="list-style-type: none"> • Forças de trabalho baixas • Sujeito a folgas mecânicas

Como se pretende uma máquina de fácil manuseamento, simples, compacta e económica a escolha final recaiu-se para a aplicação manual de pesos pois preenche os requisitos necessários. Porém com este sistema há necessidade de fabricar diferentes pesos, calibrados, para que se possa variar a gama de cargas possíveis a aplicar que, inicialmente, será pouco abrangente. Mais a frente será explicado o funcionamento do sistema adquirido.

3.1.2 Movimento e gama de velocidades

Para cada tipo de configuração de tribómetros existe um determinado tipo de movimento que caracteriza essa configuração. Todos eles têm uma parte fixa e outra móvel e, neste caso, tratando-se de um tribómetro bloco-disco é de esperar que a amostra seja a parte fixa e o disco a parte móvel (rotativa). Para que este movimento rotativo se concretize é indispensável a utilização de um motor que produza uma determinada potência para o efeito. Com o intuito de se obter a solução mais apropriada para o sistema, na Tabela 3-2 pode-se observar diferentes tipos de motor com as suas características para que se possa escolher o pretendido comparando-os entre eles.

Tabela 3-2 - Vantagens e desvantagens de motores elétricos (ELETROBRAS; et al., 2009; Heckler, 2012)

	Vantagens	Desvantagens
<i>Motores CC</i>	<ul style="list-style-type: none"> Boa precisão Controle simples de velocidade Velocidade constante mesmo sujeito a variações de carga 	<ul style="list-style-type: none"> Bastante dispendioso Requer manutenção frequente nas escovas e comutador Necessita de alimentação em corrente contínua Reparações demoradas É ruidoso
<i>Motores Universais</i>	<ul style="list-style-type: none"> Baixo custo Controle de velocidade de acordo com a necessidade da aplicação 	<ul style="list-style-type: none"> Elevado nível de ruído tanto audível como eletromagnético Pequena vida útil Não suportam trabalhos em regime contínuo
<i>Motores CA (trifásicos)</i>	<ul style="list-style-type: none"> Baixo custo Robustez Simplicidade de comando Construção simples Grande versatilidade 	<ul style="list-style-type: none"> Velocidade varia com a carga aplicada ao eixo Pouca precisão Necessidade de dispositivos especiais para controlo de velocidade Alta corrente de partida
<i>Motores de passo</i>	<ul style="list-style-type: none"> Boa precisão Robustez Longa vida útil Ausência de manutenção Mais económicos comparados com servomotores 	<ul style="list-style-type: none"> Necessita de um sistema elétrico dedicado (driver) Pequenas potências Limitações quanto à velocidade e momento de inércia pois origina erros de passo

Avaliando cada tipo de motor e, baseando-se nos requisitos pretendidos, a melhor solução recai sobre o motor de corrente alternada pelas suas diversas potencialidades, tanto a nível técnico como económico, sendo este último um fator de grande importância. Assim, tendo em conta a necessidade de variar a velocidade de rotação para respeitar a gama de velocidades, é fundamental obter um variador de frequência apropriado para o tipo de motor que posteriormente será adquirido.

3.1.3 Sistema de aquisição de velocidade

Para retirar conclusões de um determinado teste é extremamente imprescindível saber qual a velocidade a que o teste foi submetido. Para isso é necessário desenvolver um sistema que permita saber qual a velocidade utilizada durante o ensaio. Optando, novamente, por uma solução simples e económica, utilizou-se os seguintes materiais apresentados na Figura 3-2.

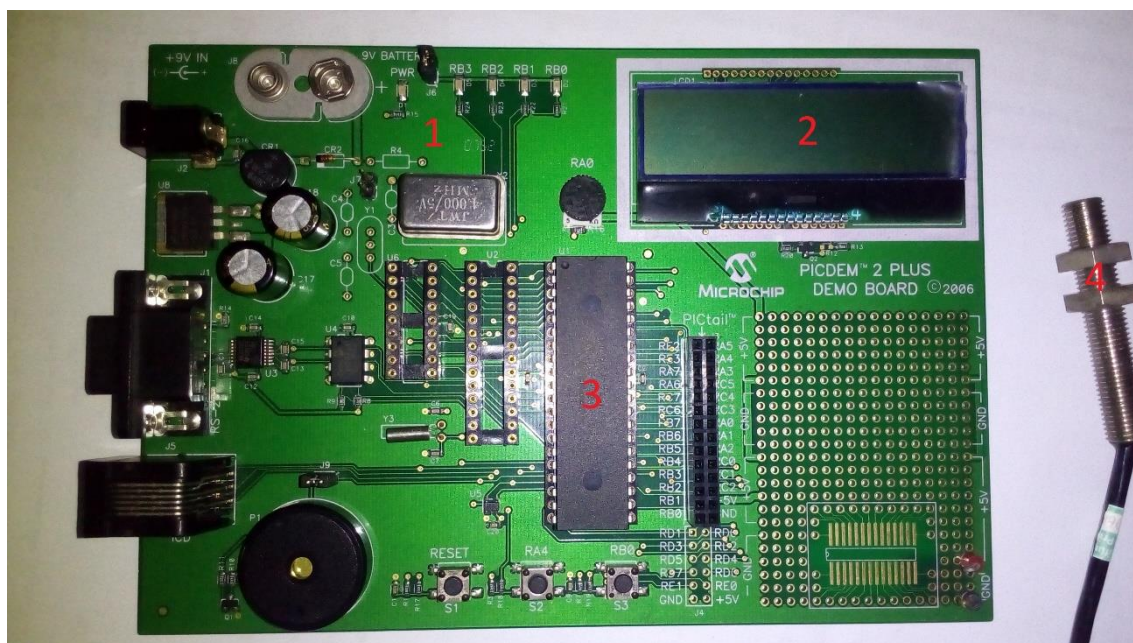


Figura 3-2 - Aquisição da velocidade de rotação. 1 - Placa PICDEM 2 PLUS 2006 com LCD (2), 3 Microcontrolador PIC16F877A, 4 - sensor indutivo

Programando o microcontrolador de maneira a que este comunique com o sensor e com o LCD facilmente se consegue ler a velocidade a que o motor se encontra.

O sistema funciona, basicamente, da seguinte forma: o sensor envia um sinal ao microcontrolador sempre que o motor efetua uma volta completa. O microcontrolador trata a quantidade de sinais recebidos do sensor e compara-os com o tempo necessário utilizado

para o efeito. Em seguida, através de uma simples fração, calcula a velocidade de rotação e escreve esse valor no LCD permitindo o seu conhecimento durante o teste.

3.1.4 Geometria da amostra

A amostra é o corpo onde será aplicado a força normal e também o que irá entrar em contacto com o disco. Na Figura 3-3 segue-se um esquema representativo da configuração do tribómetro e de como as forças estão envolvidas.

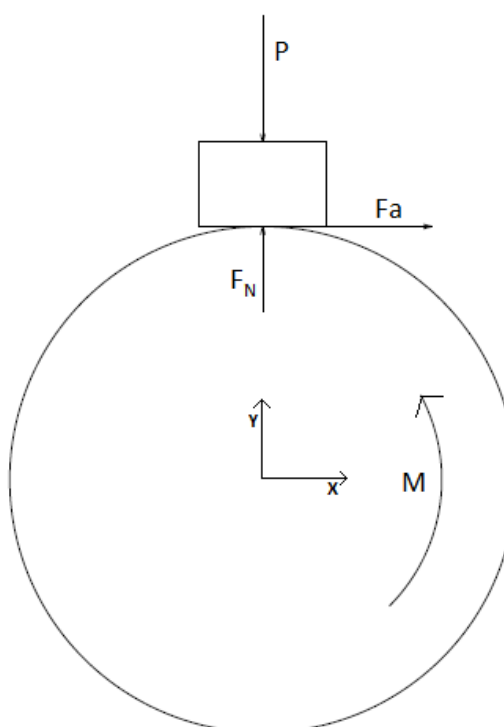


Figura 3-3 - Esquema representativo da configuração do tribómetro, sendo P a carga aplicada, F_N a força de reação, F_a a força de atrito e M o momento aplicado ao disco

O objetivo deste projeto é avaliar o desgaste provocado pelo disco na amostra em estudo. Como já se viu anteriormente que a configuração da máquina é do tipo bloco-disco então, para o efeito, definiu-se que a amostra será do tipo prismática retangular como podemos ver no esquema da Figura 3-4. Para além disso pressupôs-se que a amostra terá uma largura inferior à do disco para melhor avaliar este tipo de contacto, isto é, só haverá contacto na face circular do disco.

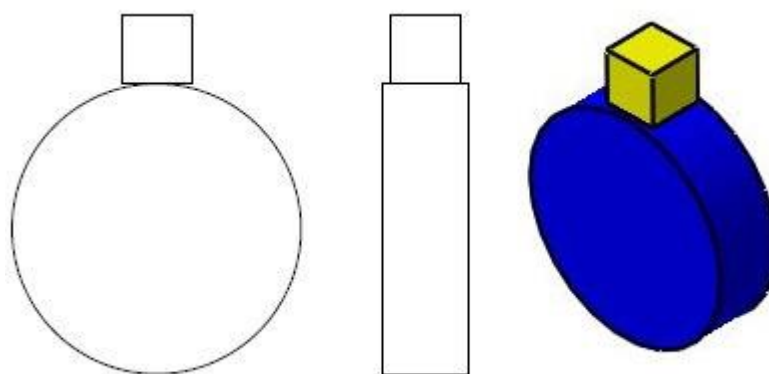


Figura 3-4 - Esquema do tipo de configuração, bloco-disco

3.1.5 Medição do desgaste

O cálculo da taxa de desgaste poderá ser feito de várias maneiras, como se viu anteriormente (capítulo 2.2.2) mas, neste caso, será baseado na perda de massa da amostra, ou seja, o corpo de ensaio será pesado antes e no final do teste. Para esse efeito recorre-se à balança A&D HR200 apresentada na Figura 3-5 com uma capacidade máxima de 210 gramas e um erro associado de uma décima do miligrama.



Figura 3-5 – Balança A&D HR200

Com a diferença de pesos medidos e utilizando a equação 2.8 do capítulo 2.2.2 (Coeficiente e taxa de desgaste) facilmente calcula-se a taxa de desgaste originada pelo ensaio realizado.

3.2 Estudo de soluções para o tribômetro idealizado.

Durante o desenvolvimento do projeto foram feitas pesquisas acerca de tribômetros atualmente existentes no mercado com o intuito de adquirir maior conhecimento de determinados sistemas e retirar ideias base. Com a informação ganha, fez-se alguns esboços que facilitaram a análise do mecanismo que, posteriormente, contribuíram para a realização dos desenhos 3D.

Neste capítulo será abordado as principais ideias dos componentes mais importantes do tribômetro, tais como, estrutura, sistema de fixação e anti rotação da amostra e sistema de aplicação de carga.

3.2.1 Estrutura

Todo o equipamento existente necessita de uma estrutura de suporte que permita acoplar vários componentes afetos a uma determinada máquina. Neste caso, a estrutura terá que suportar todos os mecanismos já abordados entre outros que seguirão mais a frente.

Inicialmente, apesar de não se ter uma dimensão limite do tribômetro pretendido, é importante salientar que se pretende um equipamento simples e de pequenas dimensões, sendo estes, os requisitos iniciais para a projeção da máquina. Tendo por base esses requisitos, idealizou-se uma estrutura, apresentada na Figura 3-6, constituída por uma placa base que suporte todo o equipamento, dois apoios verticais para o veio e uma barra superior com movimento vertical guiada por dois cilindros para permitir aplicar a carga e outros sistemas necessários, como a fixação da amostra.

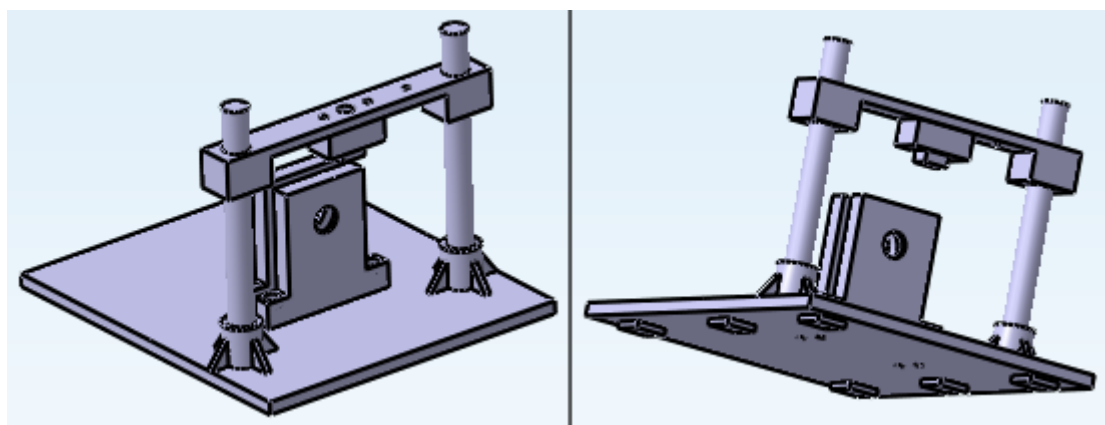


Figura 3-6 - Estrutura inicial

A solução apresentada na Figura 3-6 tem algumas desvantagens. A fraca robustez do produto é a principal pois cada sistema, apesar de ser montado sobre a mesma base, é independente um do outro o que origina a ocupação de maior espaço. De maneira a desenvolver a melhor máquina possível com os recursos disponíveis e levando ao de cima, o fator económico falado anteriormente, optou-se por usar material disponível no departamento para reduzir os custos do projeto.

Para colmatar o problema da primeira solução, desenvolveu-se uma nova solução apresentada na Figura 3-7.

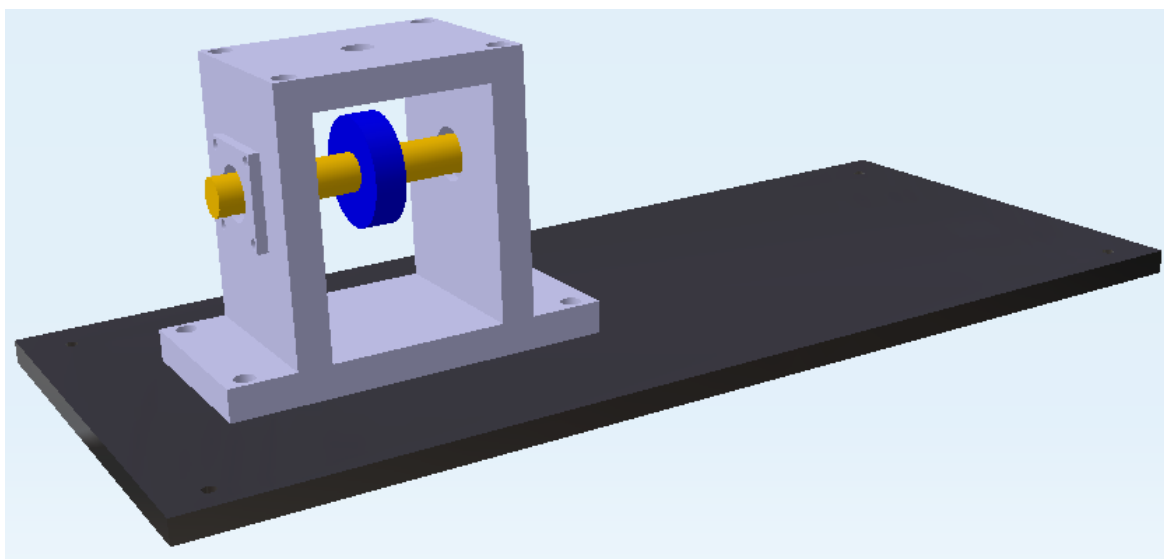


Figura 3-7 - Segunda solução para a estrutura

Observando esta segunda solução, numa primeira análise, a estrutura é muito mais rígida quando comparada com a primeira. Contudo, existe um pequeno problema nesta opção. O processo de troca de disco torna-se bastante dispendioso a nível de tempo, pois era necessário retirar o veio sempre que se quisesse fazer uma mudança.

A necessidade de alterar a configuração da estrutura era inevitável. Então, surgiu uma pequena alteração na solução anterior, observável na Figura 3-8, que consiste na deslocação dos suportes verticais, aproximando-os e colocando o disco numa das extremidades do veio.

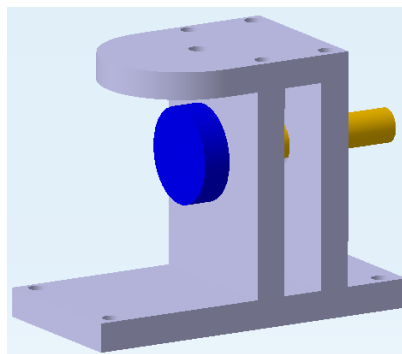


Figura 3-8 - Solução final para a estrutura

Nesta última proposta, a remoção do veio já não é necessária aquando da troca de disco. A estrutura continua com a robustez que se pretendia e a sua conceção é bastante simples bem como o seu manuseamento.

Encontrada a melhor sugestão, resta então estudar a sua envolvente relativamente aos sistemas e componentes necessários para o funcionamento do tribómetro.

3.2.2 Sistema de fixação/alojamento da amostra

Para ser possível realizar os ensaios é necessário que a amostra esteja devidamente alojada evitando que esta escape durante o teste.

Com base na estrutura final anteriormente estudada (Figura 3-8), é necessário estudar soluções para o sistema de fixação da amostra. De entre as várias possibilidades ponderadas selecionaram-se três opções bastante exequíveis.

Na primeira opção é utilizado um suporte cónico, encontrado na Figura 3-9, que apresenta uns rasgos para facilitar a entrada da amostra e o seu aperto, pois à medida que o sistema é enroscado, a parte cónica faz com que a amostra fique cada vez mais firme.

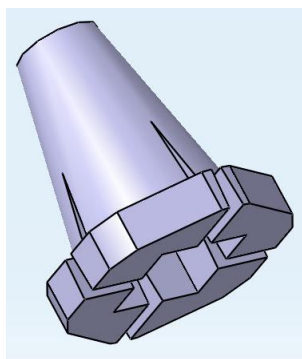


Figura 3-9 - Sistema de fixação amostra, opção 1

Na segunda opção tem-se um sistema, Figura 3-10, que consiste no aperto da amostra, através de uma placa que a pressiona contra a estrutura, recorrendo a dois parafusos.

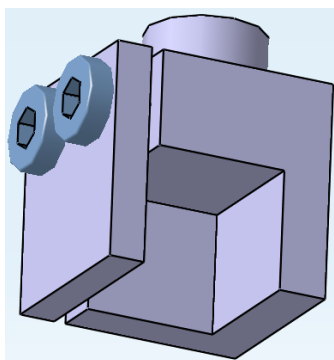


Figura 3-10 - Sistema de fixação amostra, opção 2

Relativamente à terceira opção, o sistema é bem mais simples, Figura 3-11. A amostra é produzida a uma determinada cota, ajustada à caixa do suporte, e posteriormente é colocada com uma pequena pressão impedindo que esta saia do devido lugar. De notar que nesta opção, há a necessidade de introduzir no projeto a maquinação dos cantos da caixa, pois é impossível a maquinação de uma aresta viva nessa mesma caixa.

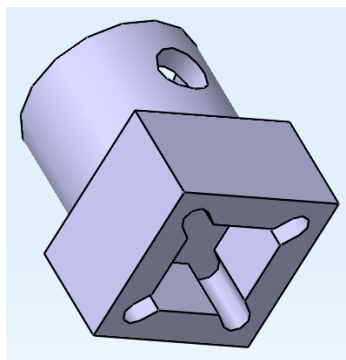


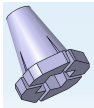
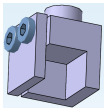
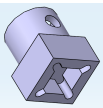
Figura 3-11 - Sistema de fixação amostra, opção 3

O furo representado na parte superior do componente serve para acoplar este ao veio de aplicação da carga.

De entre as três opções apresentadas, é necessário estudar a melhor solução. Mais uma vez, a simplicidade do tribómetro é um fator fundamental no seu desenvolvimento, por isso, a solução cairá sobre a opção que possibilita uma troca fácil e rápida de amostras permitindo elevar o potencial da máquina.

As opções foram abordadas ao mesmo nível e avaliadas segundo os requisitos. Na Tabela 3-3, é apresentada a comparação entre todas elas com base em alguns fatores.

Tabela 3-3 - Comparação entre opções de sistemas de fixação de amostras

	Opção 1 	Opção 2 	Opção 3 
Simplicidade	→	↑	↗
Fixação da amostra	↑	↗	→
Troca de amostras	→	↗	↑
Robustez	↗	→	↑
Dimensões	→	↗	↑
Custo	→	↑	↗

Analisando a tabela, a opção três é a solução mais adequada para o projeto pela sua performance relativamente à troca de amostras, à sua robustez e dimensões. Apesar de não ser a mais simples das opções, sendo ela um único componente a sua percepção é bastante fácil e o custo reduzido.

3.2.2.1 Anti rotação da amostra

Durante a realização de um ensaio num tribómetro bloco-disco, é imprescindível que a amostra esteja completamente fixa como já se viu anteriormente, isto é, evitar movimentos lineares bem como movimentos rotacionais. No capítulo anterior, o sistema de fixação impede os movimentos lineares, porém a amostra está suscetível a movimentos rotacionais.

Por forma a obter um método eficaz, adicionou-se duas guias ao suporte de fixação da amostra, como se pode observar na Figura 3-12.

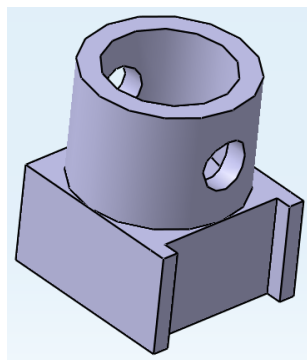


Figura 3-12 - Sistema fixação amostra com guias de anti rotação

As guias são maquinadas no suporte e este desliza sobre a placa vertical frontal da estrutura (Figura 3-8) impedindo assim o movimento rotacional.

3.2.3 Sistema Aplicação de Carga

Como abordado no capítulo 3.1.1 (Carga aplicada), a carga aplicada será efetuada por pesos mortos. Ora isto, requer o estudo de um mecanismo simples e ao mesmo tempo capaz de abranger uma certa gama de forças para possibilitar vários testes diferentes.

Depois de alguma pesquisa, surgiram três possibilidades, apresentadas na Figura 3-13, em que na primeira (a) o peso dos corpos aplicam diretamente à amostra toda a sua força, ou seja, um corpo com 2 kg aplica à amostra uma força igual ao seu peso e, na segunda e terceira a força é exercida recorrendo a um braço, isto é, o peso de um corpo passa a aplicar na amostra uma força igual ao seu peso multiplicada por um fator que depende do comprimento desse braço.

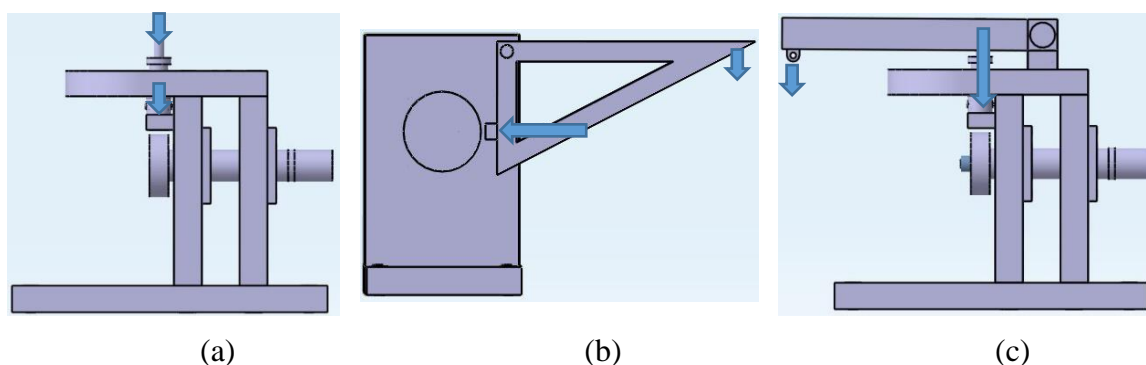


Figura 3-13 - Sistemas mecânicos de aplicação de carga. Diretamente, (a), com braço triangular (b) e com barra (c).

Com estas propostas, resta então ponderar uma escolha apropriada que satisfaça os requisitos, já que é necessário que o mecanismo seja capaz de compreender um intervalo de forças, sendo elas baixas. Analisou-se o conjunto de propostas e, na Tabela 3-4, encontra-se essa síntese.

Tabela 3-4 - Comparação entre opções de sistemas de aplicação de carga

	Força direta	Braço triangular	Barra
Simplicidade	↑	↘	↑
Intervalo de gama	↘	↑	↑
Precisão	↑	↘	↘
Robustez	↑	→	↑
Dimensões	↑	↓	→
Custo	↑	↘	↑

Analisando a tabela, há um dos casos que é logo excluído pois exige maiores dimensões e a sua robustez não é a melhor quando comparado com os outros. É o caso da opção (b) da Figura 3-13.

Fica-se então com duas soluções para o sistema requerido. Se o desejo é projetar um tribómetro para um determinado tipo de testes específicos em que a variação da carga aplicada fosse nula ou quase nula, a escolha era inclinada para o sistema de carga que aplica a força diretamente.

Sabendo que este projeto é para abranger uma variedade de testes, então é necessário examinar bem qual o sistema mais indicado. Depois de algum estudo, concluiu-se que para testes com aplicação de cargas baixas necessita-se de um sistema com a melhor precisão já que o erro associado seria menor, então a solução iria para a aplicação de carga direta. Porém, cargas maiores levariam a corpos também mais pesados e para evitar isso, o sistema que utiliza a barra seria o mais indicado.

Ora, ambicionando uma máquina com elevado potencial, surgiu a ideia de juntar as duas soluções, ou seja, num sistema único em que se pode utilizar a opção força direta e a barra dependendo do desejado aquando da realização do teste. Com isto, tem-se então na Figura 3-14 a solução final para o pretendido.

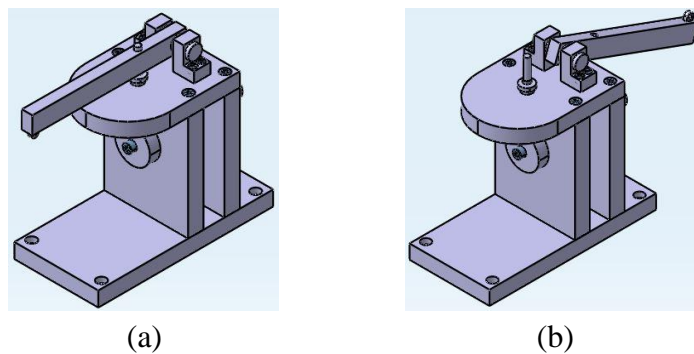


Figura 3-14 - Sistema de aplicação de carga final com opção de com ou sem barra, (a) e (b), respectivamente.

Na imagem (a) da Figura 3-14 observa-se a opção utilizando a barra e na imagem (b), coloca-se a barra para trás e utiliza-se apenas um suporte para acomodar os pesos.

CAPÍTULO 4

DIMENSIONAMENTO

Todo o projeto de uma máquina ou outro exige, sem exceção, o dimensionamento de todos os sistemas para evitar não só alguma falha de funcionamento mas também o sobredimensionamento que implica maiores gastos.

Um tribómetro não foge à regra e, claro, é imprescindível dimensionar todos os seus componentes para que num futuro a máquina responda às necessidades da melhor forma.

Depois de se conhecer a configuração e soluções para os vários sistemas até então já estudados, é fundamental averiguar que dimensões, materiais, etc. o mecanismo terá e, para isso, realizou-se o dimensionamento do motor que deverá ser utilizado e de toda a estrutura proposta e seus sistemas.

4.1 Motor

Para saber qual a potência que o motor deverá proporcionar para realizar algum tipo de teste é preciso ter em conta todas as forças envolvidas na máquina que o motor necessita de vencer.

Observando o esquema da Figura 3-3 do capítulo 3.1.4, sabe-se que a força de atrito, F_a , é a principal causadora de dissipação de energia e que o motor terá que contrariar. Para isso, é essencial calcular a sua grandeza que depende da força aplicada à amostra, P , e do coeficiente de atrito, μ , existente entre os materiais utilizados num determinado teste.

Com isto, depois de alguma pesquisa, é essencial conhecer os coeficientes de atrito que poderão estar envolvidos na máquina. Na Tabela 4-1 encontra-se alguns casos para diferentes pares de materiais.

Tabela 4-1 - Coeficientes de atrito dinâmico entre materiais (Bayer, 2002)

Materiais		Coeficiente de atrito
Aço	Aço	0,7 – 1,2
Alumínio	Aço	0,8 – 1,4
Cobre	Aço	0,7 – 1,2
Níquel	Aço	0,7 – 1,3
Acetal	Aço	≈ 0,35
Nylon	Aço	0,4 – 0,6
Poliuretano	Aço	≈ 1
Madeira	Aço	≈ 0,40
Alumínio	Alumínio	≈ 0,72
Madeira	Madeira	≈ 0,25
Vidro	Vidro	≈ 0,40

Atendendo à tabela apresentada, é de salientar que os valores do coeficiente de atrito apresentados referem-se ao atrito dinâmico, uma vez que nos testes só haverá contacto depois de o motor estar à velocidade desejada.

Para efeitos de cálculo, e para garantir que se consegue realizar testes com qualquer par de materiais, é essencial definir alguns pressupostos, apresentados na Tabela 4-2, baseando nos objetivos do tribómetro, tais como, uma máquina de pequenas dimensões, dedicada a cargas baixas e velocidades de deslizamento baixas.

Tabela 4-2 - Pressupostos do projeto

C. atrito	1,5
Carga máxima (kg)	10
Aceleração gravidade (m/s²)	9,81
Velocidade deslizamento (m/s)	3

Utilizando os dados da tabela, o passo seguinte é saber qual a potência necessário que o motor tem de produzir para garantir a realização de um determinado teste. No entanto, é fundamental estudar as dimensões que o disco poderá ter e relacioná-las com a velocidade de rotação. Para isso, realizou-se dois estudos, encontrados na Tabela 4-3, para diâmetros do disco diferentes, 50 mm e 100 mm, em que se utilizou os pressupostos anteriores.

Tabela 4-3 - Estudo para dois diâmetros diferentes do disco antagonista

Diâmetro (mm)	50,00	100,00
Força de atrito (N)	147,15	147,15
Binário (Nm)	3,68	7,36
Rotação (rpm)	1145,92	572,96

Posteriormente, utilizando os dados da tabela, calculou-se a potência exigida para cada caso utilizando a equação 4.1.

$$P_t = \frac{T \times rpm \times 2 \times \pi}{60} \quad (4.1)$$

Através da equação, em que T é o binário e rpm a rotação, a potência obtida para cada caso é a mesma. Ou seja, apesar de um caso exigir o dobro do binário do que o outro, por outro lado, exige metade da rotação que leva à igualdade da potência no valor de aproximadamente 0.44 kW.

Posto isto, o conhecimento da melhor sugestão provém de dois objetivos previamente abordados, o custo e a dimensão da máquina.

Relativamente ao custo, o estudo com diâmetro do disco de 50 requer um motor menos dispendioso já que necessita de reduzido binário. No outro caso de estudo, apesar de se poder optar por um motor de menor potência, colocando um redutor, implica um sistema mais caro pois necessita-se de maior binário.

Quanto à dimensão da máquina, o caso mais favorável, obviamente passa pelo estudo do menor diâmetro o que torna esta a solução mais indicada.

Por questões de segurança, foi aplicado um coeficiente de 1,5 à potência calculada originando um novo valor de 0,66 kW. Assim, garante-se o bom funcionamento do motor já que não é solicitado até ao limite permitindo resultados mais fiáveis.

Com o intuito de tornar o projeto mais económico, surgiu a oportunidade de utilizar uma motorização, observável na Figura 4-1 - Motor trifásico SIEMENS 1,5 kW, gentilmente cedido pelos professores António Bastos e Francisco Queirós de Melo.

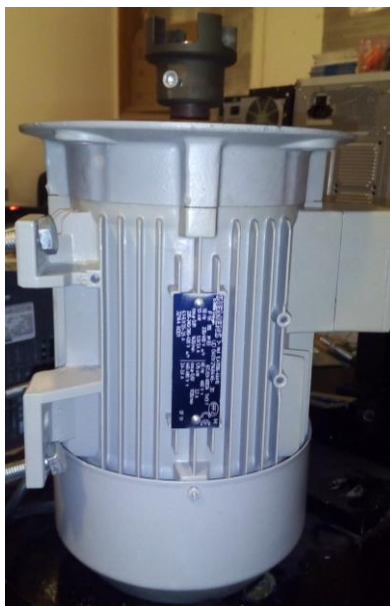


Figura 4-1 - Motor trifásico SIEMENS 1,5 kW

Todo o sistema, composto por motor e variador de frequência já dimensionado, é da SIEMENS e debita uma potência de 1,5 kW que é mais que suficiente para a concessão da máquina. No Anexo I e II encontra-se os *datashets* destes equipamentos.

4.2 Estrutura

A estrutura definida no capítulo 3.2.1 será agora alvo de dimensionamento.

Inicialmente, a placa base e as placas verticais, Figura 4-2 (a) e (b), respetivamente, foram componentes reutilizados e apenas sofreram poucas alterações, nomeadamente furações para permitir a montagem posteriormente. As suas dimensões também são observáveis na figura sendo que ambas apresentam uma espessura de 20 mm.

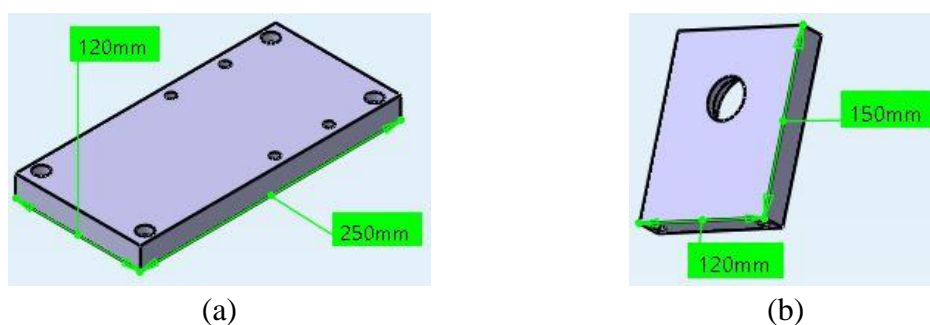


Figura 4-2 - Placas de aço já existentes: base, (a), e vertical, (b).

Posteriormente procedeu-se ao desenvolvimento da placa superior, observável na Figura 4-3, onde existe várias furações com funções diferentes.

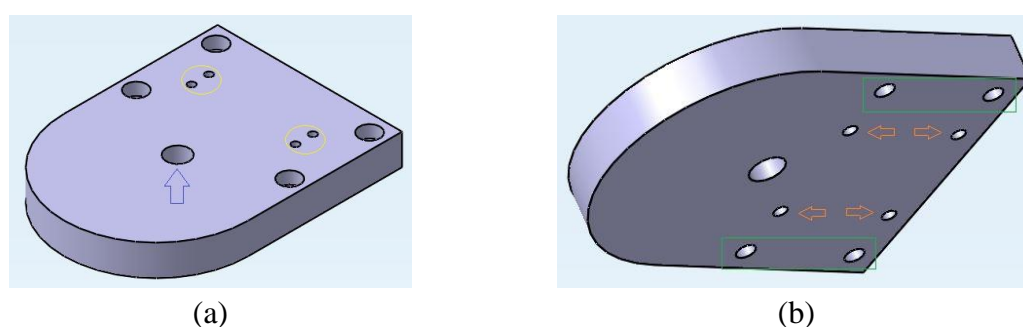


Figura 4-3 - Placa superior. Vista de cima, (a), e vista de baixo, (b).

O furo que se encontra assinalado com uma seta azul permite o movimento vertical da amostra, os furos de pequenas dimensões que estão assinalados com setas laranja

permitem colocar pinos de centragem para garantir uma boa montagem sobre as placas verticais, os assinalados com retângulos verdes são aqueles que permitem o aperto da placa, isto é, permitem a sua junção através de parafusos com as placas verticais e os furos rodeados a amarelo possibilitam o aperto do sistema de aplicação de carga.

Com a estrutura base dimensionada, a partir daí, todos os sistemas terão como referência todo o esqueleto desta, dependendo das suas dimensões.

4.3 Sistema de Aplicação de Carga

Como averiguado anteriormente, o sistema de aplicação de carga tem duas opções dependendo da força que se deseja utilizar. Neste caso, o dimensionamento deste sistema será apenas para quando se utiliza a barra, uma vez que na outra opção a força exercida pelo peso passa diretamente para a amostra.

A priori, existe a necessidade de identificar a relação de forças que a barra proporcionará. Sabendo que a carga máxima projetada para a amostra será de 10 kg, para evitar o transporte e carregamento de pesos elevados, definiu-se uma relação de 1 para 4. Ou seja, caso se pretenda realizar um teste com a máxima carga, com um simples peso de aproximadamente 2,5 kg consegue-se obter o pretendido. Porém, a barra é um corpo sólido com um determinado peso o que implica a adição de uma variável que traduz na utilização de um peso menor do que 2,5 kg. Mais a frente contemplar-se-á melhor esta relação.

Tendo agora a relação definida, é fundamental estudar as dimensões da barra para que esta suporte as condições mais adversas.

Na barra em causa, tem-se um ponto de apoio onde haverá rotação e dois pontos onde serão aplicadas determinadas forças. Na Figura 4-4 encontra-se um esquema com todas as forças envolvidas, incluindo o peso da barra.

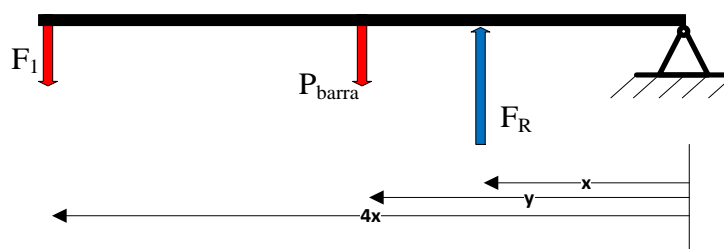


Figura 4-4 - Esquema da barra com aplicação de forças, em que F_1 é a força aplicada, P_{barra} o peso da barra e F_R a força resultante exercida pela amostra.

Falta, agora, conhecer as medidas x e y da figura, mas é fundamental conhecer previamente a posição do eixo de rotação da barra. Necessita-se, então, de projetar um suporte para a barra onde reside esse eixo de rotação. Após algum desenvolvimento, observa-se na Figura 4-5 a solução encontrada.

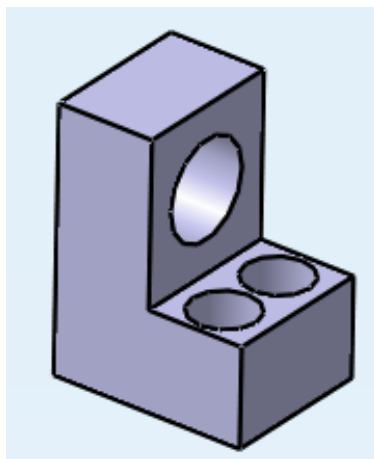


Figura 4-5 - Suporte barra do sistema de aplicação de carga

São necessários 2 suportes e um veio para formar um apoio para a barra, limitando-a à rotação e permitindo uma melhor estabilidade.

Fixando estes suportes à placa superior da estrutura, fica definida a distância x e y, segundo a representação na Figura 4-4, sendo $x = 49,75 \text{ mm}$ e $y = 102,504 \text{ mm}$. Ao obter-se as dimensões da barra, é imprescindível dimensionar o veio que permite a rotação da mesma. Para isso recorreu-se ao *software* MDSolids 4.0 para simular a carga a que este estará sujeito. Na Figura 4-6 pode-se observar os resultados obtidos, ao nível da tensão de corte, momento fletor, inclinação e deflexão, para um força de 100N (P_1).

Posteriormente, é necessário calcular o diâmetro mínimo, através da equação 4.2 (Morais, 2013), que permite ao veio resistir às forças nele empregues.

$$d_{min} \geq \sqrt[3]{\frac{32 \times \gamma_s}{\pi \times \sigma_0} \times \sqrt{M_b^2 + \frac{3}{4} \times M_t}} \quad (4.2)$$

Onde, γ_s é o coeficiente de segurança, σ_0 a tensão de cedência do material (AISI 1045 com $\sigma_0 = 530 \text{ MPa}$), M_b o momento fletor e M_t o momento torsor que para este caso concreto é nulo.

Com o dado do momento fletor obtido e com base nas características do material utilizado, obtém-se um diâmetro mínimo de 4,5 mm. Porém a pensar numa possível evolução

e para evitar desperdício de material utilizou-se um diâmetro de 20 mm, pois disponha-se de varões de diâmetro um pouco maior do que o que se pretendia.

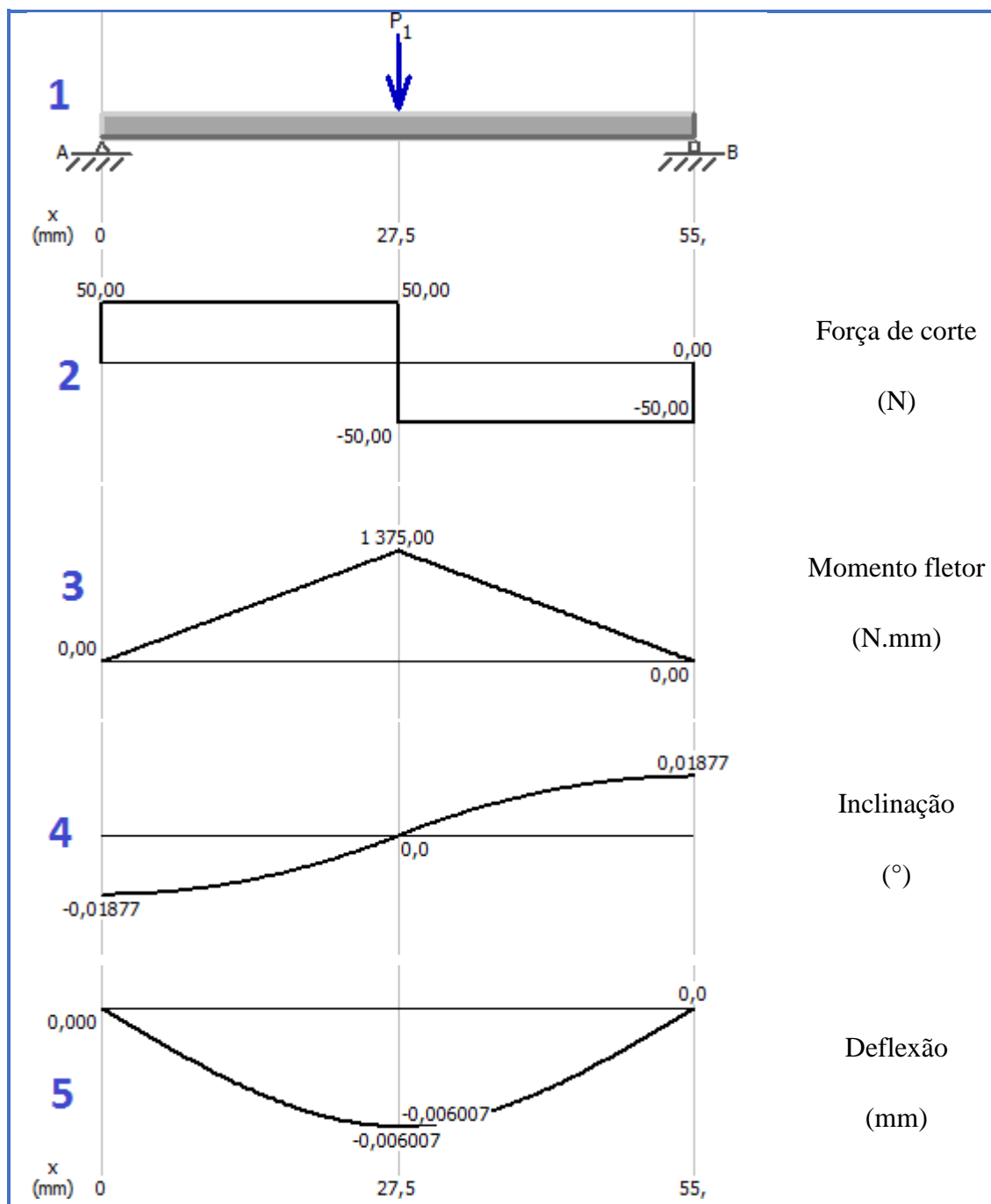


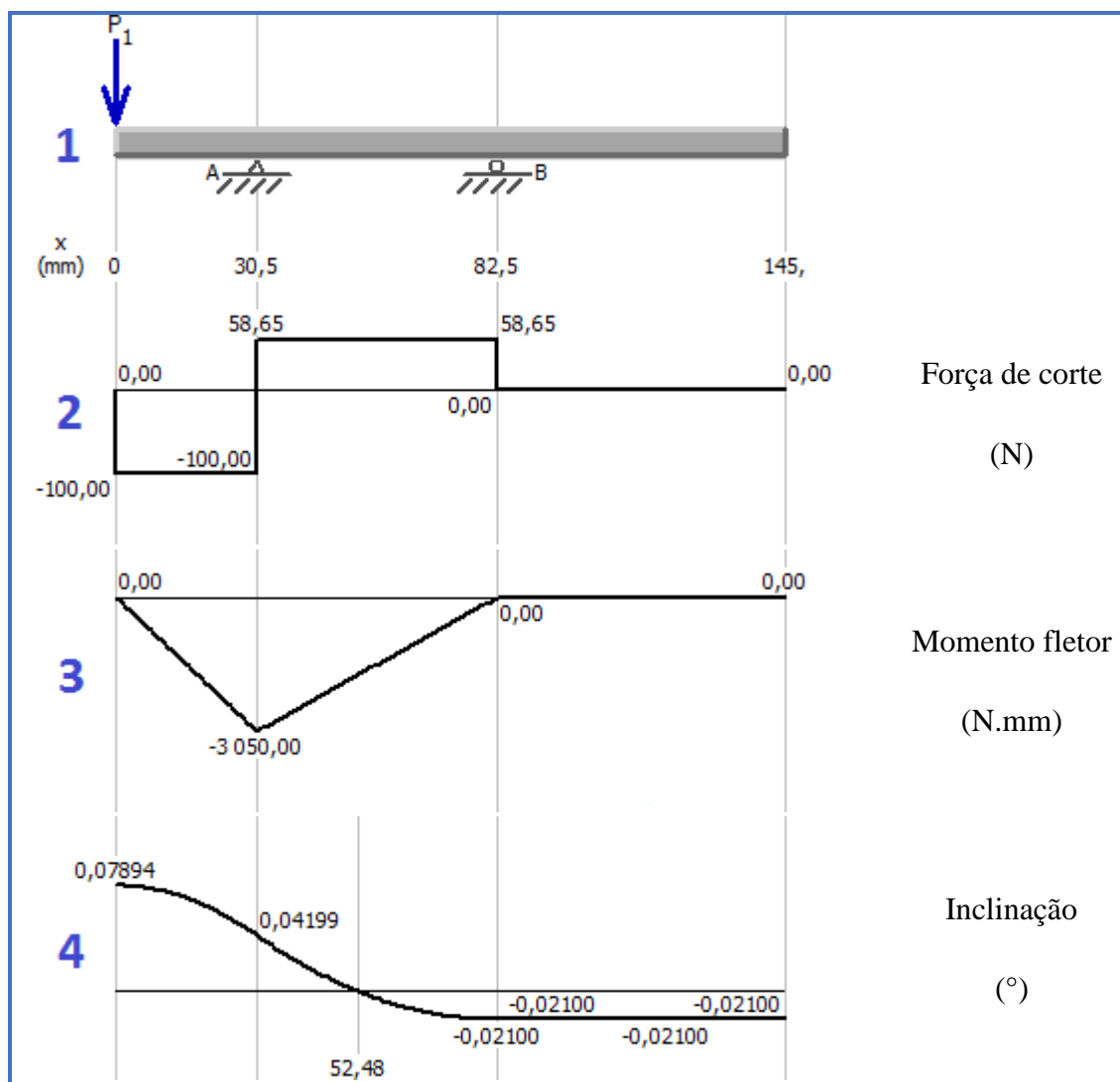
Figura 4-6 - Esquema da força aplicada no veio de suporte da barra, (1), e respectivos diagramas (2 – tensão de corte, 3 – Momento fletor, 4 – Inclinação, 5 - Deflexão)

Obviamente fica-se com um veio sobredimensionado com capacidade para sustentar maiores cargas.

4.4 Veio principal

O veio principal é aquele que irá transmitir a potência do motor para o disco onde será aplicada determinada força, portanto o dimensionamento deste componente é muito importante para garantir o bom funcionamento da máquina.

Usando o mesmo método utilizado anteriormente para o veio do sistema de aplicação de carga, simulou-se as forças aplicadas no veio, como se pode observar na Figura 4-7.



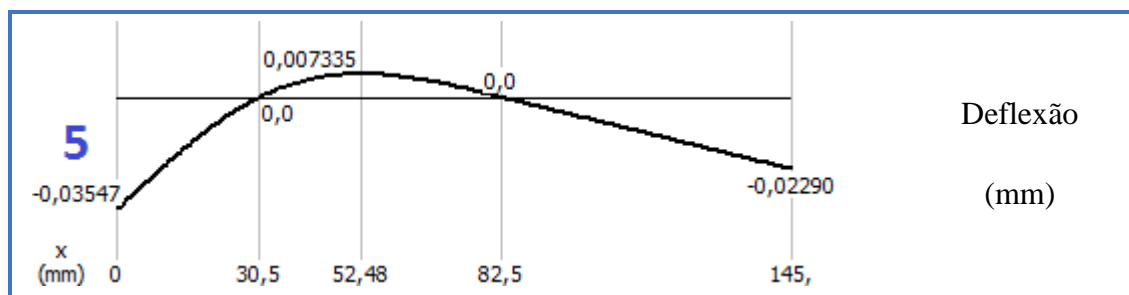


Figura 4-7 - Esquema da força aplicada no veio principal, (1), e respectivos diagramas (2 – tensão de corte, 3 – Momento fletor, 4 – Inclinação, 5 - Deflexão)

A próxima etapa é usar a equação 4.2 e calcular o diâmetro mínimo para o veio, sendo de 6 mm. Porém, baseando-se mais uma vez sobre os aspetos anteriormente ditos acerca do desperdício de material, recorreu-se a um veio de 25 mm de diâmetro. Outro fator que se refletiu nesta decisão foi a possibilidade de utilizar um acoplamento disponível, já dimensionado para o motor em causa.

4.5 Rolamentos

O uso de rolamentos é importante para reduzir o atrito num movimento rotacional quando sujeito a cargas bem definidas e, neste caso, como é exigido que a máquina tenha a melhor performance, necessita-se que a dissipação de energia, ao nível mecânico, seja a menor possível pois esta é fundamental para o desenrolar de um determinado teste.


Mais uma vez, aproveitando ao máximo todo o material e equipamento ao dispor no departamento, o dimensionamento dos rolamentos será realizado ao contrário. Isto é, em vez de calcular a carga estática e dinâmica que estes terão de suportar e depois selecionar aqueles que garantem as exigências, como se tem disponíveis dois rolamentos de rígidos de esferas, então o processo é averiguar se são capazes de resistir a essas cargas em determinadas condições. Optou-se por usar estes rolamentos pois também suportam cargas axiais, porém relativamente baixas.

Num primeira fase, é necessário conhecer as características dos rolamentos em causa. Portanto, sabendo que estes são produzidos pela SKF, através da referência consegue-se retirar a informação pretendida e que se pode observar na Tabela 4-4.

À primeira vista sabe-se que estes rolamentos têm bem mais capacidade do que se necessita. Porém, uma análise analítica é sempre uma mais valia para garantir o desempenho da máquina.

Tabela 4-4 - Características Rolamento de rolos cilíndricos (SKF)

Capacidade

	Carga dinâmica máxima, (C)	14,8 kN
	Carga estática máxima, (C ₀)	7,8 kN

Através das equações 4.3 e 4.4 (Morais, 2013), pode-se determinar qual a capacidade máxima destes rolamentos.

$$C_0 = f_s P_0 \quad (4.3)$$

Onde f_s é o coeficiente de segurança e P_0 a carga equivalente.

$$L_{10} = \left(\frac{C}{P_0} \right)^p \quad (4.4)$$

Onde L_{10} representa a vida em milhões de rotações com 90% de fiabilidade e o expoente p é igual a 3 pois trata-se de rolamentos de esferas.

Como ao longo do dimensionamento do projeto a carga máxima aplicada é de aproximadamente 100 N, então pode-se concluir que os rolamentos garantem o processo. No entanto, relativamente à carga dinâmica pode-se calcular qual o tempo de vida dos rolamentos a nível funcional independentemente das condições a que estará sujeito (lubrificação, temperatura). Logo, substituindo na equação 4.4 os valores já mencionados obtém-se:

$$L_{10} = \left(\frac{14800}{100} \right)^3 = 3,24 \times 10^6$$

Ou seja, significa que, os rolamentos compreendem uma quantia elevada de rotações garantindo elevado tempo de funcionamento. De salientar que este valor é referente à utilização da carga máxima dimensionada. Como ao longo do projeto todos os sistemas se

encontram sobredimensionados, a capacidade da máquina aumentará e, por outro lado, o tempo de vida dos rolamentos irá diminuir no caso concreto de aplicação de maiores cargas.

4.6 Suporte da amostra

O componente apresentado na Figura 4-8, já anteriormente estudado, é responsável pelo alojamento da amostra que será sujeita a um determinado teste. Obviamente devido à força de atrito este componente irá sofrer tensões ao longo do ensaio. Para garantir a estabilidade, procedeu-se ao estudo de tensão e deformação da peça para o caso mais crítico, utilizando o *software* SOLIDWORKS.

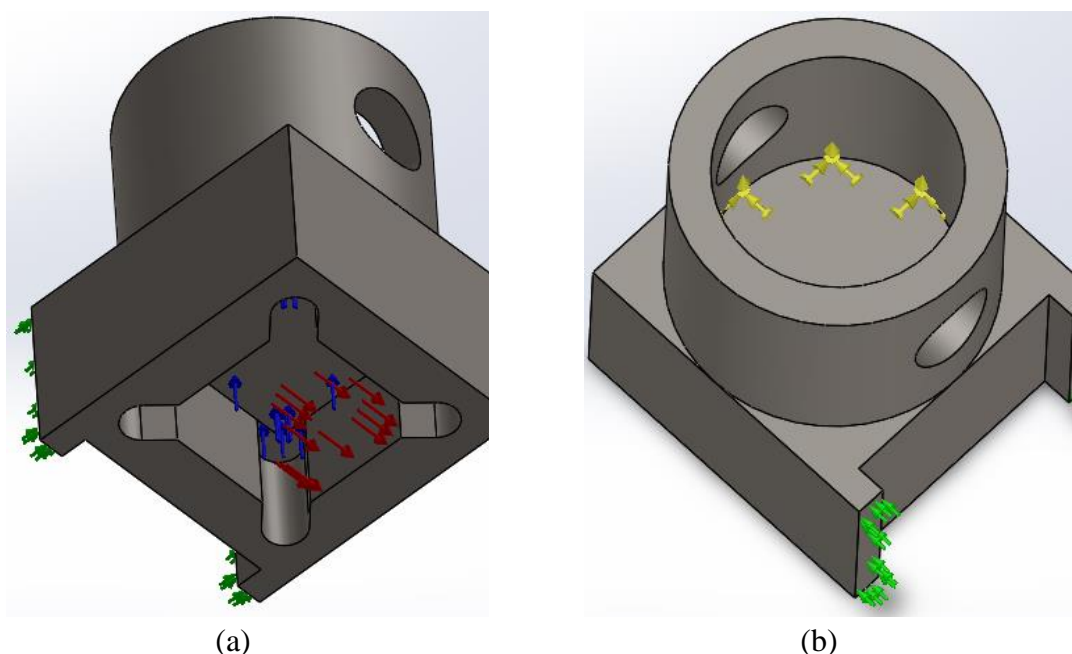


Figura 4-8 – Representação das forças aplicadas e fixações da amostra, com vistas isométricas. A verde é a parte deslizante, a azul relaciona a força aplicada, a vermelho a força de atrito e a amarelo parte fixa.

De notar que a envolvente crítica da peça é a parte inferior visto que é nesta zona onde estará maiores tensões. O dimensionamento desta peça teve como base respeitar as dimensões já encontradas para os suportes verticais e horizontal superior (Figura 4-2 (b) e Figura 4-3, respetivamente), no entanto assumiu-se que o alongamento máximo não poderá exceder os 5×10^{-2} mm.

Para a simulação considerou-se o mesmo valor do coeficiente de atrito (1,5) utilizado no capítulo 4.1, e a carga máxima até agora utilizada. Com isto, obteve-se, aproximadamente, uma força de atrito de 150 N.

O material utilizado para a simulação corresponde, novamente, ao aço de construção CK45 (AISI 1045 com $E = 205 \text{ GPa}$ e $\sigma_{\text{cedência}} = 530 \text{ MPa}$).

Numa abordagem inicial, e para ajudar a obter resultados fiáveis procedeu-se a sucessivas simulações com vários refinamentos da malha onde se pode observar os diferentes resultados (tensão máxima e deformação máxima) na Tabela 4-5 e no gráfico da Figura 4-9.

Tabela 4-5 - Tensão máxima e Deformação máxima para diferentes malhas

Malha [mm]	1,5	1,25	1	0,75	0,5	0,4	0,3	0,2
Tensão [MPa]	17,145	16,771	16,518	18,678	23,564	29,319	34,601	37,563
Deformação [x10 ³ mm]	1,309	1,322	1,340	1,345	1,354	1,363	1,365	1,366

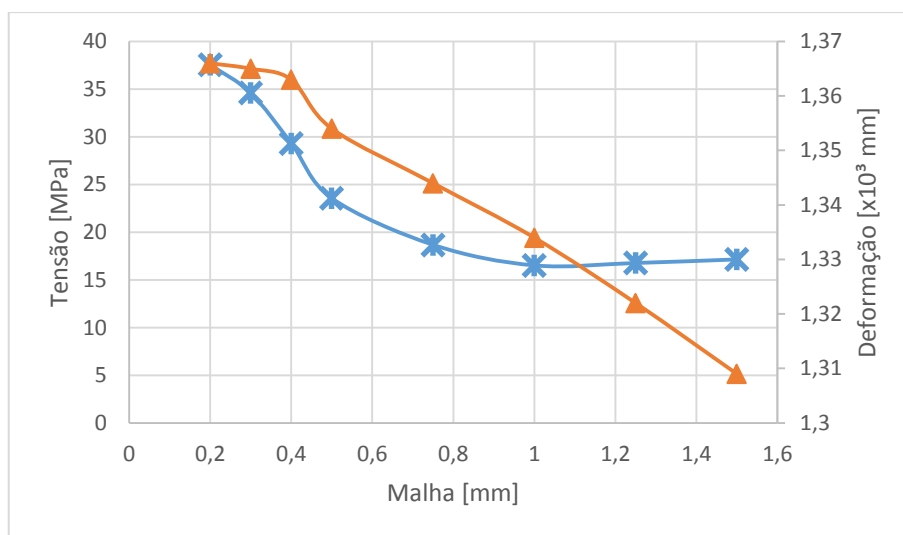


Figura 4-9 - Gráfico deformação e tensão para as várias malhas

Através dos dados obtidos, conclui-se que com 0,2 mm a deformação encontra-se praticamente estabilizada. Portanto a malha será definida com este refinamento como se pode observar na Figura 4-10. Porém, nos resultados obtidos para qualquer malha, pode-se afirmar que não existe qualquer problema quanto a este componente uma vez que os valores estão bem abaixo do que o requerido.

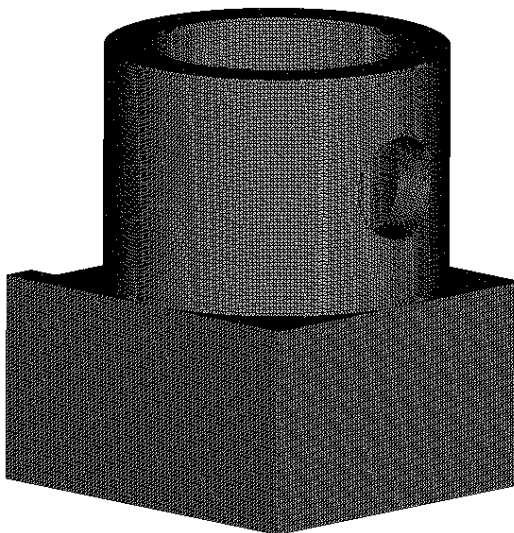


Figura 4-10 - Suporte com malha de 0,2 mm

Para uma melhor compreensão, sabendo desde já quais os resultados para a malha definida, na Figura 4-11 e na Figura 4-12 encontram-se as simulações, de tensão e deformação, respectivamente, do componente. Estas simulações foram realizadas para o caso estático e utilizando as condições extremas.

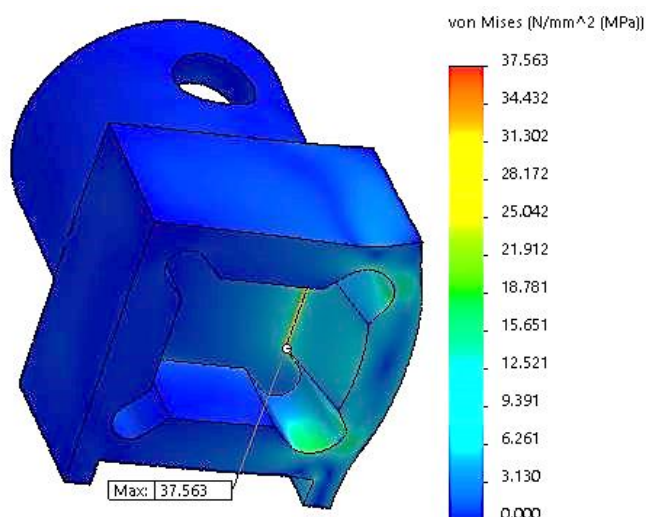


Figura 4-11 - Simulação das tensões obtidas durante a realização de um teste

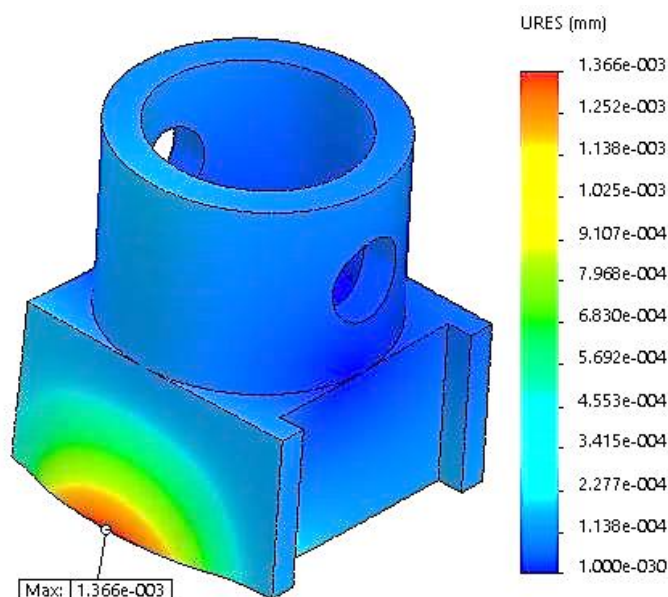


Figura 4-12 - Simulação da deformação obtida durante a realização de um teste

Através das imagens anteriores consegue-se perceber as zonas críticas do componente e, como era de esperar, no caso da tensão esta encontra-se no interior da peça na zona de alojamento da amostra, já no caso da deformação é o oposto, isto é, do lado de fora do suporte.

Com isto, chega-se à conclusão que as peças mais solicitadas durante a realização de um ensaio, encontram-se viáveis em todos os aspetos e, por isso, resta finalizar toda a fase de projeto detalhado.

4.7 Simulação com todo o conjunto

Nos capítulos anteriores viu-se que os sistemas mais propícios a causar falhas durante o funcionamento da máquina, estão devidamente dimensionados na certeza de que tudo decorrerá da melhor forma. Porém para fortalecer o projeto procedeu-se a uma simulação com toda a configuração da máquina, a exceção da parte motora.

Na Figura 4-13 e na Figura 4-14, pode-se observar os resultados alcançados, onde se pode ver de uma maneira geral, a distribuição de tensão e deformação pelo conjunto e também compreender as zonas mais desfavoráveis agora com os sistemas unidos num só.

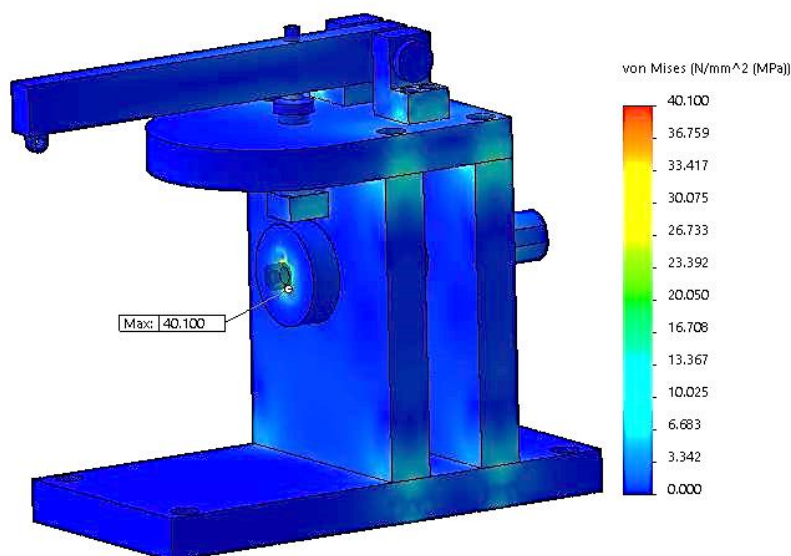


Figura 4-13 – Simulação do conjunto ao nível da tensão

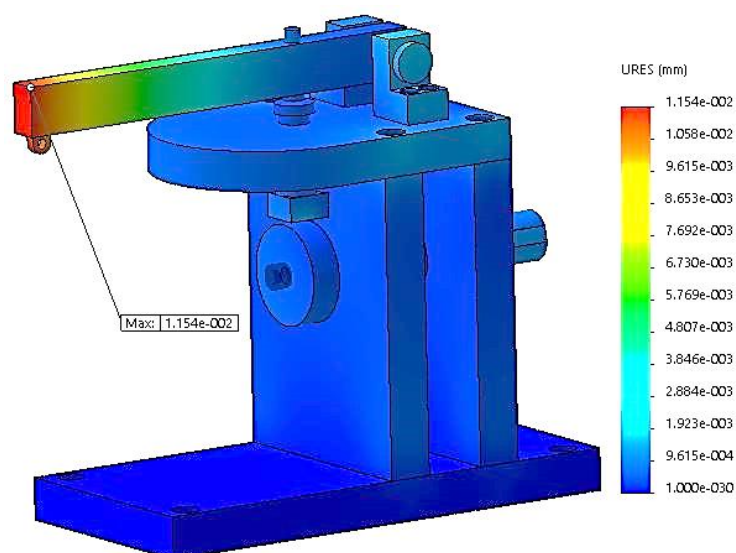


Figura 4-14 – Simulação do conjunto ao nível da deformação

Com estes resultados, conclui-se que os valores da tensão máxima e da deformação máxima do conjunto, 40,1 MPa e $1,154 \times 10^{-2}$, respetivamente, encontram-se dentro dos limites admissíveis, reforçando assim, a robustez do projeto.

Para avaliar a performance da máquina, surgiu a ideia de sujeitar a máquina a maiores cargas de maneira a apresentar as suas capacidades. Perante isto, recorreu-se ao método utilizado até então, mas de forma contrária. Ou seja, em vez de se utilizar uma determinada carga bem definida para se obter os resultados ao nível da tensão e deformação, que depois eram avaliados e comparados com os limites expostos, procedeu-se a sucessivas simulações com o intuito de aumentar a carga aplicada progressivamente até acordar um valor para o

qual a deformação máxima e/ou tensão máxima estivessem próximas dos limites admissíveis. Para isso, a tensão não podia exceder os 530 MPa do material utilizado (Aço AISI 1045) e a deformação não podia ultrapassar o valor imposto anteriormente, 5×10^{-2} mm.

Depois de algumas simulações, apresentam-se na Figura 4-15 e na Figura 4-16 os resultados obtidos para a carga máxima de 100 N (aplicada na barra) que poderá ser utilizada no tribómetro.

Apesar de a tensão, aproximadamente de 68 MPa, estar muito abaixo da tensão de cedência do material, a deformação, aproximadamente de $4,5 \times 10^{-2}$ mm, encontra-se bastante próxima do limite admissível.

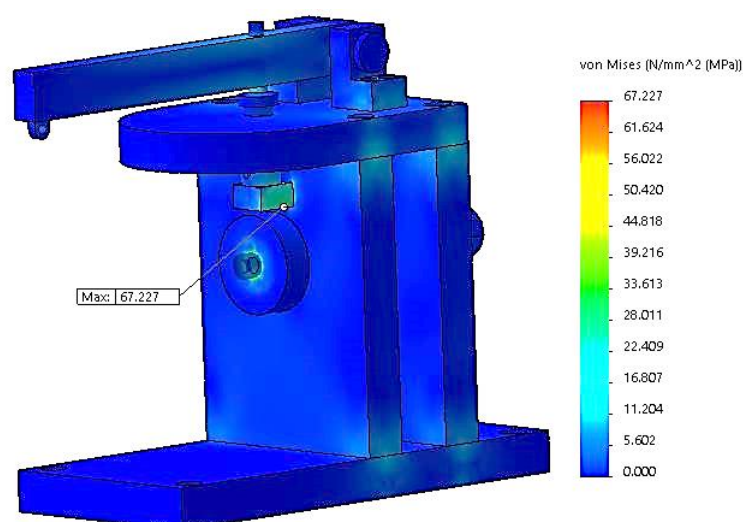


Figura 4-15 – Simulação com a carga máxima admissível ao nível da tensão

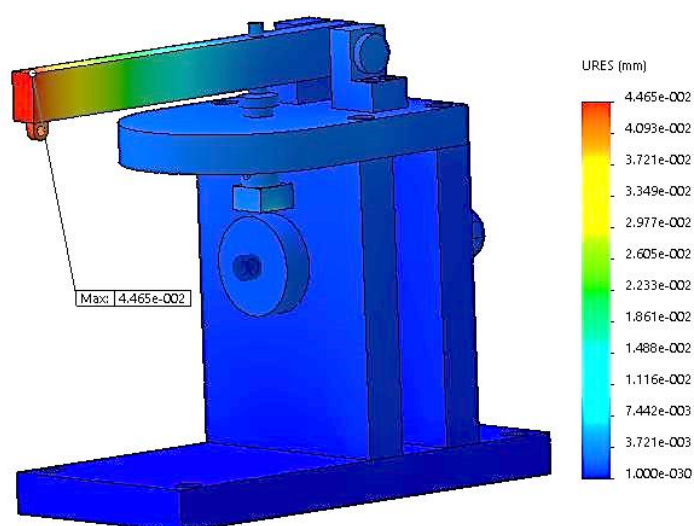


Figura 4-16 – Simulação com a carga máxima admissível ao nível da deformação

4.8 Tribómetro – Solução Final

Após o alongado estudo das soluções de todos os sistemas, encontrou-se a solução final para o tribómetro idealizado como se pode ver na Figura 4-17.

Foi adicionada uma mesa de suporte, que se encontrava disponível, para que todo o conjunto fica-se fixo, garantindo um bom apoio de todos componentes. Outro dos benefícios da utilização desta mesa é que possibilita a colocação próxima da parte mecânica e de toda a parte elétrica.



Figura 4-17 - Solução final para o tribómetro

4.9 Síntese

Esta parte do trabalho é bastante importante e imprescindível para qualquer projeto. É nela que se compara todas as possibilidades de sistemas e se estuda todo o mecanismo para definir a melhor solução.

O aspeto económico foi um dos principais fatores na decisão de certos sistemas já a obtenção de uma máquina de reduzido custo era bastante importante. Perante isto, as soluções para cada determinado sistema passavam sempre por tentar aproveitar ao máximo material disponível no departamento.

Ao longo do dimensionamento do projeto, reparou-se que o tribómetro, apesar de inicialmente ter como requisito uma carga máxima de 100 N, encontra-se sobredimensionado o que possibilitou abranger um maior intervalo de gama de cargas.

De salientar que com a utilização de componentes, tais como, variador de frequência, motor, mesa, acoplador, rolamentos e algumas placas, gentilmente cedidos pelos professores António Bastos e Francisco Queirós de Melo, o projeto tornou-se mais económico sendo que, esses componentes foram a base de todo o desenvolvimento.

Todos os desenhos do tribómetro são apresentados no anexo III, incluindo as dimensões do disco e da amostra (componentes de ensaio).

PARTE III

TRIBÓMETRO

CAPÍTULO 5

CONSTRUÇÃO E MONTAGEM

Concluída e aprovada a fase de projeto, segue-se para a construção e montagem física do equipamento. Neste capítulo abordar-se-á todo o processo de obtenção dos componentes e a montagem do tribómetro em si.

Perante isto, será explicado com mais pormenor a conceção de cada sistema e a aquisição de seus componentes.

5.1 Estrutura de suporte

Grande parte da estrutura da máquina utilizou peças reaproveitadas o que a tornou bastante simples e económica. Toda ela é composta por placas de aço que sofreram alteração para permitir a montagem entre elas.

A primeira a ser estudada é a placa base, observável na Figura 5-1. Nesta apenas foi necessário realizar uma limpeza devido à oxidação e alguns furos para permitirem a ligação a um dos suportes verticais da Figura 5-2, visto que outros dois foram aproveitados.



Figura 5-1 - Placa base



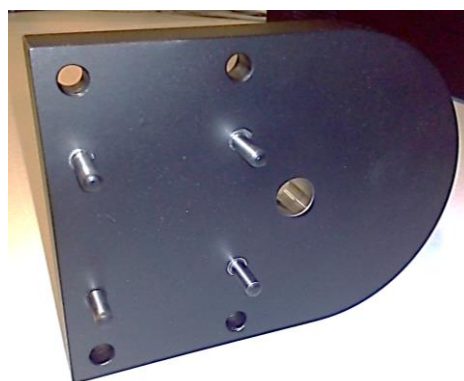
Figura 5-2 - Suporte vertical com alojamento do rolamento

Relativamente aos suportes verticais, Figura 5-2, apenas foi indispensável uma limpeza à oxidação. Estes já possuíam o alojamento para os rolamentos rígidos de esferas, também observáveis na mesma figura e a tampa de proteção dos mesmos.

Dentro da estrutura base apenas foi necessário produzir a placa superior que interliga os suportes verticais e concede ao equipamento boa robustez.



(a)



(b)

Figura 5-3 - Suporte superior com vista de cima, (a), e vista de baixo, (b).

5.2 Veio motor

O veio do motor Figura 5-4 é um dos componentes mais importantes do tribómetro, pois é ele que transmite ao disco a potência aplicada pelo motor.



Figura 5-4 - Veio de transmissão de potência e disco antagonista

Para a sua produção foi necessário torneamento e retificação para conceber a sua forma redonda, fresagem para aplicação de uma chaveta e furação para possibilitar a aplicação de dois pinos com o intuito de não só evitar o escorregamento entre o disco e o veio como também permitir maior suporte aquando da transmissão da carga. Outra furação foi necessária para permitir a fixação do disco com auxílio de um parafuso.

5.3 Sistema aplicação de carga

O conjunto apresentado na Figura 5-5 foi concebido essencialmente por fresagem. Este sistema, como já se viu anteriormente, permite uma relação de 1 para 4 aquando da aplicação de carga por meio de pesos mortos.

Os dois suportes serão fixados à placa superior (Figura 5-3) através de parafusos e o veio irá fazer a ligação entre eles e a barra. Para melhor rigor aplicou-se dois casquilhos nas laterais da barra para que esta apenas tenha liberdade na rotação e não no deslocamento.



Figura 5-5 - Sistema completo para a aplicação de carga.

O furo passante assinalado representa o eixo de aplicação de carga coincidente com o eixo da amostra.

5.4 Sistema de suporte da amostra

Todo o conjunto do suporte da amostra da Figura 5-6 permite a transmissão da carga aplicada pela barra até à amostra e o seu alojamento.

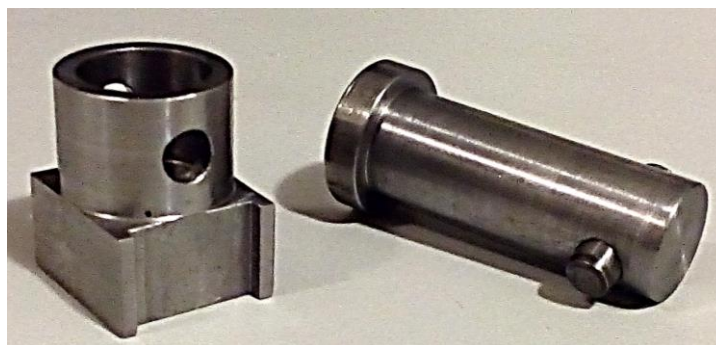


Figura 5-6 - Sistema de suporte da amostra

Este sistema simples será aplicado na placa superior do tribómetro. Para isso o veio deverá entrar pela parte superior da placa e o suporte da amostra pela parte inferior. A ligação

entre os dois será feita por meio de um pino somente para impossibilitar a separação dos dois componentes já que, a caixa cilíndrica do suporte tem a mesma forma do veio, o que confere uma boa área de contacto entre as duas peças.

5.5 Montagem do tribómetro

Depois da aquisição de todos os componentes e sistemas do tribómetro surge a oportunidade da sua montagem.

Na Figura 5-7 encontram-se todos os componentes que exigiram algum tempo de estudo e concessão e que agora estão disponíveis para o próximo passo, montagem.

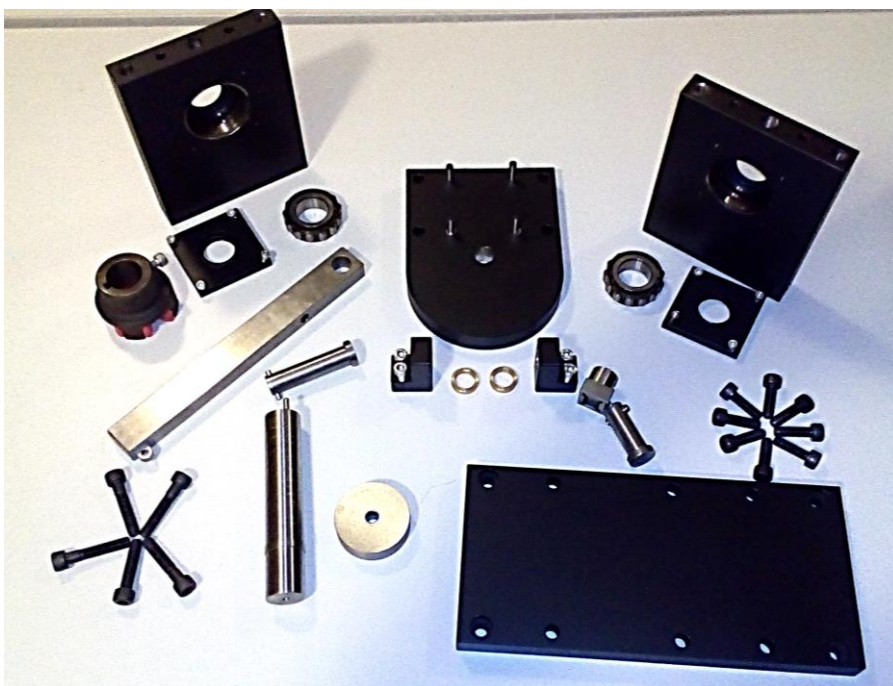


Figura 5-7 - Parte mecânica do tribómetro toda desmontada

Para uma melhor abordagem à constituição do tribómetro, a sua montagem é realizada em duas grandes etapas.

Na primeira etapa são montadas todas as peças mecânicas onde, basicamente, se utilizam parafusos para a união dos componentes/sistemas. Esta etapa é bastante simples e inicia-se, desde logo, com a colocação da mesa que sustenta todo o equipamento no local pretendido. Para uma melhor compreensão, são descritos a seguir todos os passos a realizar

nesta etapa e, no esquema da Figura 5-8, pode-se ver a evolução à medida que se avança o processo:

1. Com a mesa no devido lugar, prende-se o motor e o variador de frequência à mesa com auxílio de parafusos;
2. Seguidamente introduz-se os rolamentos nos suportes verticais. Estes são ligados, posteriormente, à placa base da estrutura e coloca-se o conjunto em frente ao motor;
3. Introduz-se o veio principal entre os suportes verticais e pode-se agora prender a placa base à mesa;
4. Coloca-se a placa superior por cima da estrutura até então montada e une-se o conjunto;
5. Este passo compreende agora a montagem do sistema de aplicação de carga que inclui a ligação dos suportes da barra à placa superior, e introdução do veio pertencente a este conjunto nos furos coincidentes das várias peças;
6. Finalizando, coloca-se o varão roscado que sustentará os pesos na extremidade da barra, o veio do suporte da amostra e o pino de aplicação de carga na barra.

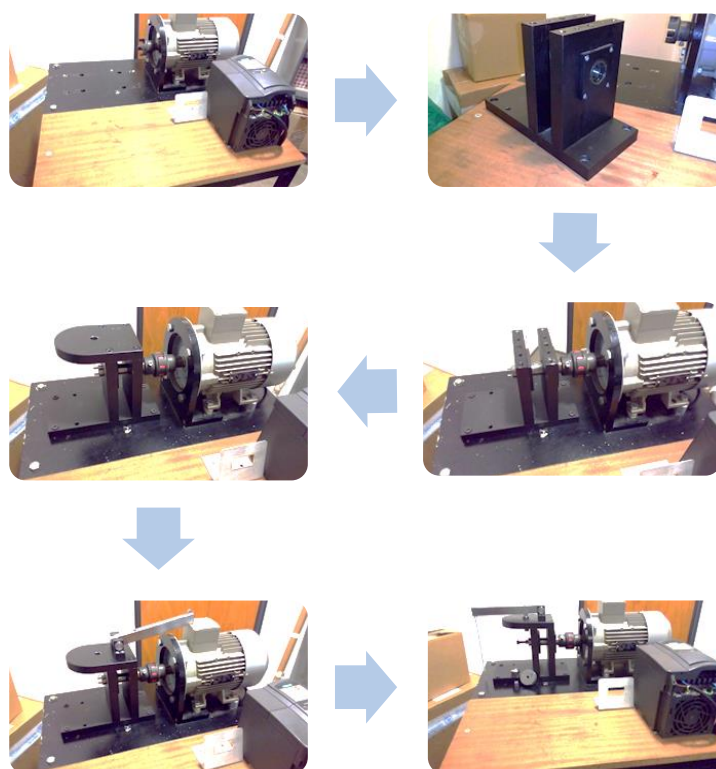


Figura 5-8 - Evolução do processo de montagem da parte mecânica

A segunda etapa compreende a parte elétrica do tribómetro. Do mesmo modo, descreve-se então cada passo das ligações:

1. O variador é alimentado com a tensão da rede, corrente alternada 220 V, que por sua vez alimenta o motor, através de uma ligação trifásica, que se encontra com a configuração em estrela;
2. Posteriormente é colocado o sensor no devido lugar e efetuada a conexão deste com o microcontrolador, Figura 5-9.



Figura 5-9 - Localização do sensor

3. Para permitir variar a velocidade, recorre-se a um potenciômetro ligado à entrada analógica do variador.
4. Para finalizar colocou-se um botão *on/off*, conectado a uma entrada digital (24 V), que permite o arranque e paragem do motor

Na Figura 5-10, encontra-se o tribómetro completo já com todas as ligações efetuadas.



Figura 5-10 - Tribómetro completo

5.5.1 Gama de cargas do tribómetro

Com o tribómetro pronto a realizar ensaios, é necessário conhecer as suas características e adquirir pesos mortos calibrados para alcançar resultados mais precisos.

Na Figura 5-11 pode observar-se os pesos obtidos para posterior aplicação na máquina, onde apresentam uma forma cilíndrica.



Figura 5-11 - Pesos mortos para aplicação no tribómetro

Estes pesos podem ser utilizados individualmente ou combinados entre si permitindo efetuar várias combinações de cargas.

Na Tabela 5-1 encontra-se a força que cada peso exerce, individualmente, na amostra com a utilização da barra proposta. Importa salientar que, como se viu anteriormente, é fundamental considerar o peso dos componentes que afetam todo o processo de aplicação de carga. Para calcular este acréscimo considera-se o peso de alguns dos componentes, isto é:

- Suporte da amostra $\Rightarrow 0,047$ kg;
- Veio amostra $\Rightarrow 0,065$ kg;
- Barra $\Rightarrow 0,620$ kg;
- Varão roscado $\Rightarrow 0,040$ kg

Se o ensaio a realizar não utilizar a barra, então a força a adicionar é de:

$$(0,047 + 0,065) \times 9,81 \approx 1,1 \text{ N}$$

Recorrendo à utilização da barra, então é necessário acrescentar o valor de:

$$1,1 + 0,620 \times 9,81 \times \frac{102.504}{49.75} + 0,040 \times 9.81 \times 4 \approx 15,6 \text{ N}$$

Sendo $102,504/49,75$ a relação entre a distância do centro de massa da barra ao eixo de rotação da mesma e a distância do eixo de aplicação de carga ao mesmo eixo de rotação.

Com isto, as forças apresentadas na tabela para cada peso, já contam com este acréscimo.

Tabela 5-1 - Correspondência entre peso aplicado e força exercida na amostra

	Pesos [kg]	Força amostra [N]
P₁	0,158	21,790
P₂	0,330	28,540
P₃	0,357	29,599
P₄	1,640	79,944
P₅	1,675	81,318
Total	4,160	178,829

Através da Tabela 5-1 pode-se concluir que com os pesos adquiridos obtém-se uma gama de cargas desde 15,2 N quando não se utiliza qualquer peso, até 239 N aproximadamente, quando é utilizado todos os pesos disponíveis.

5.6 Síntese

A construção e montagem do tribómetro permite compreender melhor o funcionamento da máquina. Ao longo do seu desenvolvimento apercebe-se que a máquina abrange um maior intervalo de cargas do que o imposto em capítulos anteriores. Em resumo, tem-se então um tribómetro capaz de utilizar cargas até 179 N e velocidades até 3,7 m/s correspondente à velocidade máxima do motor, 1450 rpm, e utilização de discos de 50 mm de diâmetro.

Contudo, relativamente à gama de cargas do tribómetro, não é possível aplicar qualquer carga, ou seja, é necessário conhecer quais as possíveis combinações de pesos que se pode utilizar. Posto isto, na Tabela 5-2 encontra-se todas essas combinações, ordenadas por ordem crescente da força aplicada, incluindo a opção de exclusão da barra quando se

desejar realizar testes com cargas baixas, que ajuda a obter a carga desejada de forma mais rápida.

Tabela 5-2 – Cargas possíveis no tribómetro

Pesos	Massa (kg)	Sem barra [N]	Com barra [N]
P1	0,158	2,649	21,790
P2	0,330	4,336	28,540
P3	0,357	4,601	29,599
P1+P2	0,488	5,886	34,740
P1+P3	0,515	6,151	35,799
P2+P3	0,687	7,838	42,548
P1+P2+P3	0,845	9,388	48,748
P4	1,640	17,187	79,944
P5	1,675	17,530	81,318
P1+P4	1,798	18,737	86,144
P1+P5	1,833	19,080	87,517
P2+P4	1,970	20,424	92,893
P3+P4	1,997	20,689	93,953
P2+P5	2,005	20,768	94,267
P3+P5	2,032	21,033	95,326
P1+P2+P4	2,128	21,974	99,093
P1+P3+P4	2,155	22,239	100,153
P1+P2+P5	2,163	22,318	100,467
P1+P3+P5	2,190	22,583	101,526
P2+P3+P4	2,327	23,927	106,902
P2+P3+P5	2,362	24,270	108,275
P1+P2+P3+P4	2,485	25,477	113,102
P1+P2+P3+P5	2,520	25,820	114,475
P4+P5	3,315	33,619	145,671
P1+P4+P5	3,473	35,169	151,871
P2+P4+P5	3,645	36,856	158,620
P3+P4+P5	3,672	37,121	159,680
P1+P2+P4+P5	3,803	38,406	164,820
P1+P3+P4+P5	3,830	38,671	165,880
P2+P3+P4+P5	4,002	40,358	172,629
P1+P2+P3+P4+P5	4,160	41,908	178,829

CAPÍTULO 6

ENSAIOS E ANÁLISE DE RESULTADOS

Com o tribômetro pronto a ser testado, é necessário prever os materiais a serem utilizados e as condições a que vão ser sujeitos.

Para realizar estes ensaios, optou-se por utilizar discos antagonistas de aço AISI 1045, com as suas características descritas na Tabela 6-1. Relativamente às amostras a opção recai sobre um material macio, para permitir avaliar a máquina de uma forma geral, ou seja, se é capaz de realizar testes ou necessita de reformulação/otimização. Então, utilizou-se amostras de alumínio 1050 com as suas características também descritas na Tabela 6-1. No anexo IV encontra-se os desenhos com as respetivas dimensões da amostra e do disco.

Tabela 6-1 – Características dos materiais utilizados²

Material	Densidade [g/cm ³]	Módulo de Elasticidade [GPa]	Coefficiente de Poisson	Tensão de cedência [MPa]	Dureza de Brinell [HB]
Alumínio 1050	2,70	69	0.33	103	30
Aço AISI 1045	7.85	206	0.29	530	179

² www.matweb.com

6.1 Condições iniciais

Com o intuito de abranger um pouco as capacidades da máquina, realizou-se 3 grupos de ensaios com condições diferentes. Como se estava limitado a 5 discos antagonistas, com diâmetro de 50 mm e largura de 15 mm a distribuição destes pelos diversos grupos está apresentada na Tabela 6-2. Juntamente, encontra-se a rugosidade média do disco (R_a), medida no rugosímetro Hommel Tester T1000E em dois pontos, com um comprimento total de palpação igual a 4,8 mm, e as condições de ensaio impostas.

Tabela 6-2 - Condições utilizadas nos ensaios para cada disco

Grupo	Nº Disco	R_a [μm]	Velocidade [rpm]	Distância [m]	Carga [N]
1	1	3,06	300	2000	21,790
	2	2,63	300	2000	21,790
2	3	2,68	600	2000	48,748
3	4	2,34	600	2000	21,790
	5	2,38	600	2000	21,790

Relativamente às amostras, estas foram pesadas antes do início dos testes para, à posteriori, avaliar a perda de peso gerada em cada ensaio. Perante isto, existe então condições para se realizar os ensaios e retirar os dados resultantes destes para, posteriormente, proceder-se a uma análise. De salientar que, relativamente à carga aplicada em cada ensaio, para o grupo 1 e 2 o peso utilizado é o P_1 , ou seja, 0,158 kg. Para o grupo 2 utilizou-se uma combinação dos três pesos mais pequenos, P_1 , P_2 , P_3 , ou seja 0,845 kg.

Encontra-se no anexo IV um manual de utilização deste tribómetro que facilita a sua manipulação na realização de testes.

6.2 Avaliação dos resultados

Concluídos os ensaios, é imprescindível o tratamento dos resultados para compreender as causas e efeitos dos mesmos. Como primeiro passo, pesou-se novamente as

5 amostras ensaiadas e determinou-se as perdas de peso de cada uma apresentadas na Tabela 6-3.

Tabela 6-3 - Peso das amostras antes e depois dos testes e respectiva diferença

Amostra	1	2	3	4	5
$P_{inicial} (g)$	4,1662	4,1590	4,1555	4,1529	4,1430
$P_{final} (g)$	4,1272	4,1212	3,9760	4,1109	4,1004
$\Delta P (g)$	0,0390	0,0378	0,1795	0,0419	0,0426

Para facilitar a compreensão e ajudar na análise dos resultados, a Figura 6-1 contempla as amostras e os discos depois da realização dos testes. Pode-se observar as diferenças entre o estado da superfície entre os componentes.

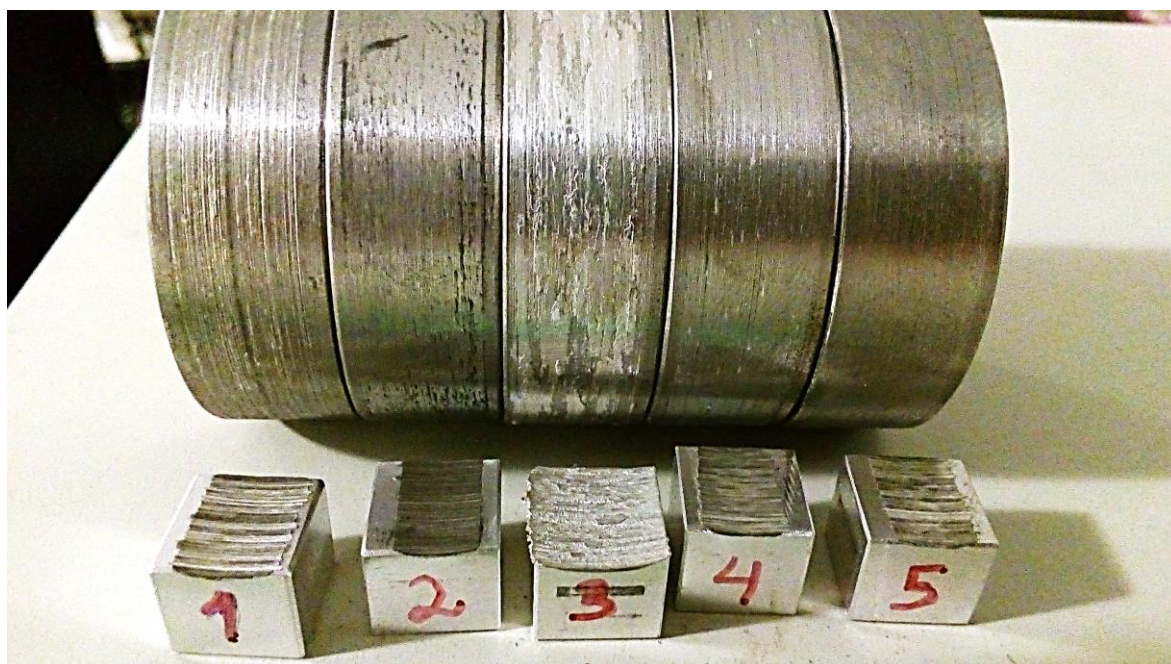


Figura 6-1 - Estado dos conjuntos amostra disco depois dos testes

Da Figura 6-1 pode-se afirmar que os discos 1 e 3 são aqueles em que as superfícies se encontram mais danificadas sendo mais acentuado no disco 3. Relativamente à perda de peso, as amostras pertencentes a esses discos, também foram as que providenciaram maior perda de material.

Para o caso 3, as condições impostas para o teste deste conjunto são mais severas que a dos outros. Posto isto, é extremamente importante afirmar que não foi possível concluir este teste. Isto porque depois de percorridos cerca de 1225 m de distância o motor simplesmente parou, por segurança, uma vez que a mostra aderiu completamente ao disco. Para retirar o conjunto que se encontrava com uma temperatura elevada, foi necessário dar uma pancada na amostra para que esta se soltasse do disco. Mesmo assim, pesou-se a amostra depois de se encontrar algumas horas em repouso, para arrefecer. Perante isto, era de esperar que esta apresenta-se maior perda de material.

Relativamente às amostras 1, 2, 4 e 5, os testes foram concluídos nas melhores condições. A temperatura das amostras também aumentou nestes casos porém, esse aumento não foi acentuado. No final de cada ensaio os conjuntos eram retirados manualmente e a temperatura era perfeitamente suportada.

Para estes conjuntos, está apresentado um gráfico na Figura 6-2 com o coeficiente de desgaste para cada amostra

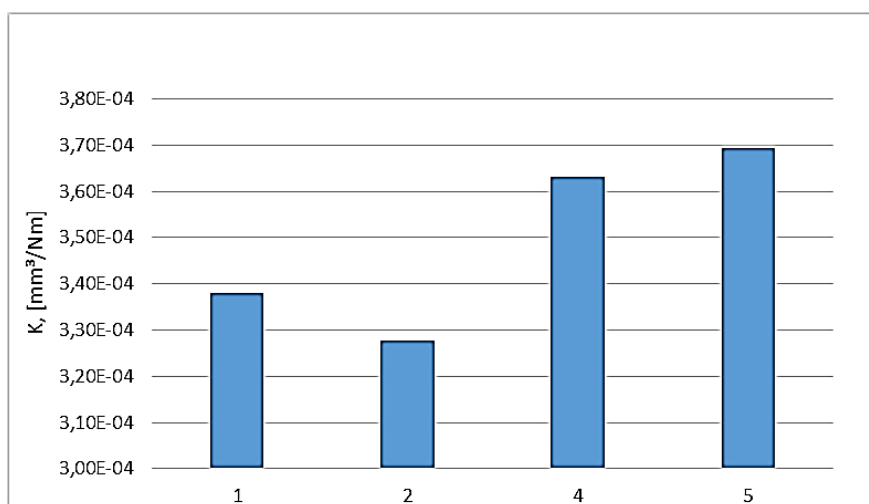


Figura 6-2 - Coeficiente de desgaste das amostras

Segundo Rabinowicz (1981) a ordem de grandeza da contante de desgaste K para um contacto a seco entre diferentes materiais (alumínio-aço), ronda os 10^{-4} . Perante isto, pode-se afirmar que os valores obtidos são aceitáveis. Gousia et al (2016) ensaiaram, num tribómetro *ball-on-disk*, várias amostras de alumínio 1050 com e sem reforço de molibdénio (MoS_2) contra aço e obtiveram um coeficiente de desgaste de $4,07 \times 10^{-4} \text{ mm}^3/\text{Nm}$ correspondente às amostras sem reforço. Ou seja, acrescenta-se maior valor aos resultados alcançados através do tribómetro.

De acordo com Bayer (2004) o coeficiente de desgaste obtido para a liga de alumínio Al2014 com 5% de SiC quando submetido contra aço é de $2 \times 10^{-4} \text{ mm}^3/\text{Nm}$. Comparando

este valor com os resultados obtidos, era de esperar que estes sejam superiores, já que a liga Al2014 apesar de ser diferente da utilizada no presente trabalho apresenta um reforço de carboneto de silício que a torna mais resistente ao desgaste.

Tendo em conta que a amostra 1 e 2 foram realizadas nas mesmas condições, houve uma pequena diferença entre elas devido, por ventura, à rugosidade do disco 1 ser maior, o que originou um aumento do coeficiente de desgaste e maior riscamento do disco depois do ensaio como se pode observar na Figura 6-1. Relativamente às amostras 4 e 5, existe apenas uma ligeira diferença entre as duas.

Tendo em conta que as amostras 1 e 2 foram submetidas a uma velocidade de 300 rpm que equivale a aproximadamente 0,79 m/s e as amostras 4 e 5 a 600 rpm, ou seja, sensivelmente 1,57 m/s, conclui-se que o aumento da velocidade de deslizamento provoca um aumento do coeficiente de desgaste.

6.3 Perda de volume teórica vs. Perda de volume real

De maneira a adquirir uma melhor perspectiva dos resultados, surgiu a oportunidade de comparar a perda de volume teórica com a perda de volume real obtida. Recorreu-se então, ao *software* CATIA V5, para ajudar a calcular a perda de volume teórica. O processo utilizado é demonstrado na Figura 6-3 e consiste em medir, nas faces de desgaste (faces onde ocorreu contacto com os discos) as zonas com ausência de contacto do disco. Seguidamente com o diâmetro do disco a interceitar o limite dessas zonas facilmente se obtém o volume da concavidade criada no ensaio com ajuda de alguns comandos do programa.

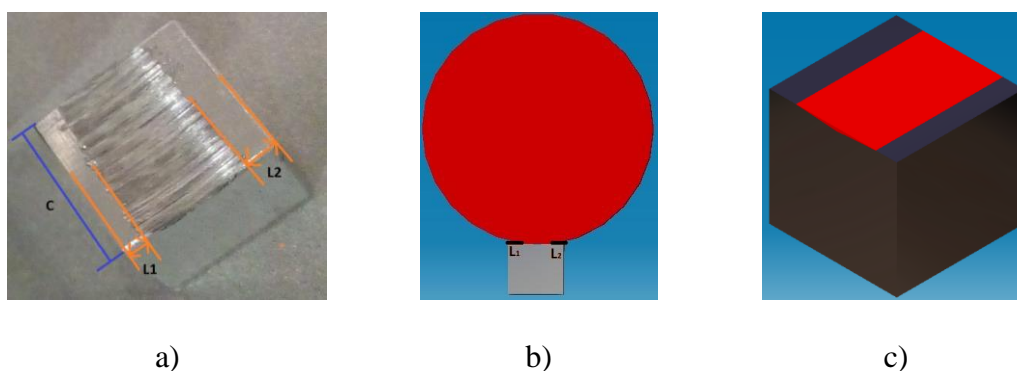


Figura 6-3 – Processo de medição, na face de desgaste, das zonas não desgastada, a), onde L_1 e L_2 representam as larguras e C representa o comprimento total da amostra. Interseção entre amostra disco b). Volume de perda de material obtido, c).

No gráfico da Figura 6-4 encontra-se os resultados teóricos para as 4 amostras (1, 2, 4 e 5) e os resultados reais calculados através da perda de peso e com a ajuda da equação 2.5 (capítulo 2.2.2).

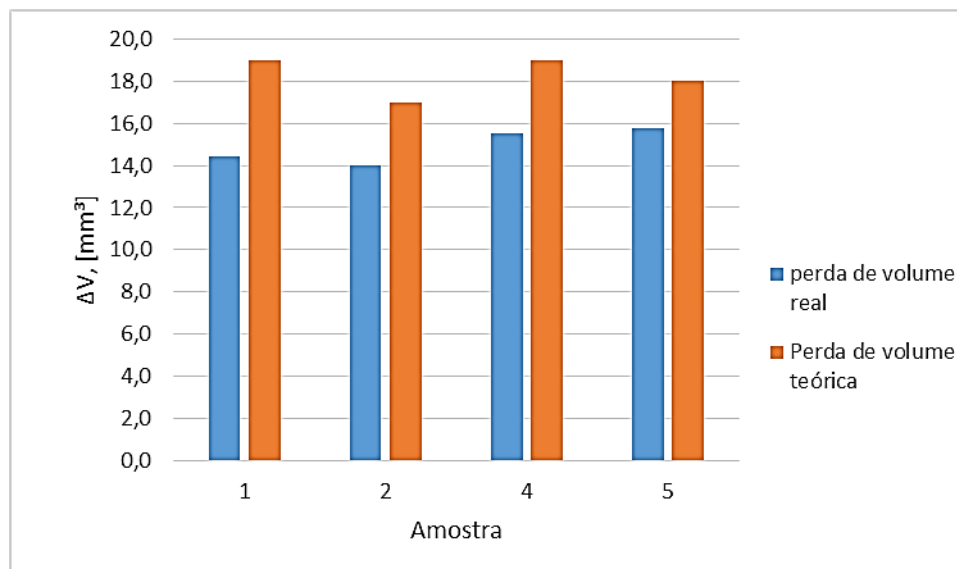


Figura 6-4 - Perda de volume real vs. perda de volume teórico

Da análise do gráfico, observa-se claramente que o volume perdido real está abaixo do teórico. Ora, isto era de esperar uma vez que no cálculo teórico é considerado que a concavidade apresenta uma superfície perfeita, quando na realidade não é, pois existe uma elevada rugosidade no local onde existiu interação dos materiais.

CONCLUSÕES

CAPÍTULO 7

CONCLUSÕES

A tribologia é uma área científica que abrange uma panóplia de outras áreas e, por isso, o seu estudo requer elevada dedicação e tempo disponível. A pesquisa realizada permitiu aprofundar conhecimentos nesta área e foi um pilar importante para a realização deste trabalho.

Na indústria, existe grande competitividade entre fabricantes de sistemas mecânicos e o objetivo de cada um é produzir com a maior qualidade possível a um preço reduzido. Para isso, o estudo dos mecanismos é imprescindível e bastante aprofundado para garantir a melhor solução. Sendo o tempo de vida útil um dos aspetos mais importantes, a tribologia permite aos produtores estudar o seu produto ao nível do desgaste no contacto de componentes. Para o efeito, existe uma máquina denominada de tribómetro que permite a avaliação do contacto entre materiais. Neste equipamento é possível reproduzir a configuração desejada e controlar várias variáveis de modo a que os ensaios sejam o mais próximo possível da situação real e, por conseguinte, os resultados sejam mais fiáveis.

Para o tribómetro do presente documento era requerida uma configuração bloco-disco, onde o contacto entre materiais começa por ser linear e vai aumentando a sua área com o decorrer do teste. Esta configuração não é específica para um determinado sistema mas, de uma forma geral, permite avaliar mecanismos em que a área de contacto aumenta à medida que é solicitado. O equipamento foi projetado de raiz com determinados objetivos a serem cumpridos, nomeadamente, ser capaz de realizar ensaios com o intuito de determinar o coeficiente de desgaste de materiais de uma forma simples e económica.

Com todo o projeto definido, passou-se para a produção do tribómetro. Durante este processo teve-se o cuidado de produzir as peças com as tolerâncias conforme o estabelecido o que proporcionou uma forte ajuda na posterior montagem do equipamento.

Após a obtenção do tribómetro fisicamente definido, era necessário definir as suas capacidades/limites a que este pode ser sujeito. A partir da simulação já realizada no dimensionamento da estrutura sabe-se que esta suporta uma carga mais elevado do que o esperado, cerca de 415N na amostra.

A velocidade de rotação dada pelo motor pode ser alterada através do variador de frequência com recurso a um potenciómetro. Este varia uma tensão entre 0 e 10 V que corresponde a 0 e 1450 rpm (3,7 m/s), respetivamente.

Depois de toda a definição técnica, submeteu-se a máquina a testes para avaliar o seu desempenho e, para isso, optou-se por utilizar um material que apresenta-se um desgaste acentuado.

Relativamente ao funcionamento da máquina em si, é importante considerar alguns aspetos. Na obtenção dos discos, apesar das suas tolerâncias definidas em anexo, é aconselhável a sua maquinação montados no veio para evitar que estes tenham uma certa excentricidade. Por outro lado, o suporte da amostra mostrou bastante capacidade no seu desempenho permitindo a boa montagem das amostras.

No que toca a vibrações e ruído, o tribómetro revelou bons resultados. As vibrações são quase nulas e o ruído provém apenas do motor e também, em menor escala, do contacto não lubrificado entre dois metais.

Abordando aos resultados obtidos, onde foram ensaiados 3 tipos de testes diferentes, pode concluir-se que o bom funcionamento do tribómetro, pois desenvolveu resultados esperados. Com o aumento de carga o aquecimento das amostras de alumínio é, de tal modo, elevado que a amostra aderiu ao disco. Por outro lado com um aumento de velocidade o coeficiente de desgaste também aumenta como era esperado com base na pesquisa realizada no estado da arte. Em relação aos valores, propriamente ditos, estes encontram-se dentro da ordem de grandeza de outras ligas de alumínio.

Finalizando, após todo o trabalho realizado na presente dissertação, o tribómetro apresenta-se pronto e capaz de realizar ensaios com qualquer tipo de materiais sendo que as condições de teste estão restritas às impostas pelo equipamento. Mediante os objetivos propostos, pode concluir-se que a máquina responde às necessidades impostas inicialmente.

Em anexo, encontra-se o procedimento para a realização de um ensaio. A sua compreensão é bastante simples e não requer elevado tempo na sua execução.

7.1 Trabalhos futuros

Apesar de o tribómetro ter respeitado os requisitos e ter conseguido realizar testes, apenas permite controlar duas variáveis importantes, carga e velocidade. Dado que quanto mais fatores são controlados, mais rigor existe nos resultados, era interessante, como trabalhos futuros, abordar os seguintes temas:

- I. Instrumentar a máquina para permitir mais variáveis controladas, nomeadamente, temperatura e coeficiente de atrito.
- II. Avaliar a repetibilidade da máquina com elevado número de testes para as mesmas condições
- III. Comparar os resultados do equipamento com outro do mesmo género ou até mesmo de configuração diferente
- IV. Testar outros tipos de materiais
- V. Aplicar um sistema que permita realizar ensaios lubrificados e testar
- VI. Analisar dinamicamente o tribómetro ao nível de vibrações, variações térmicas entre outros

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ANEXOS

ANEXO I

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On CD 2 for the selection and configuring tools, you will find the SD configurators for low-voltage motors, MICROMASTER 4 inverters, SINAMICS G110 and SINAMICS G120 inverter chassis units as well as SINAMICS G120D distributed frequency inverters and SIMATIC ET 200S FC frequency converters for distributed I/O, complete with:

- Dimension drawing generator for motors
- Data sheet generator for motors and inverters
- Starting calculation
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Hardware and software requirements

- PC with 500 MHz CPU or faster
- Operating systems
 - Windows 98/ME
 - Windows 2000
 - Windows XP
 - Windows NT 4.0 (Service Pack 6 or higher)
- 256 MB work memory (minimum)
- Screen resolution 1024 x 768, graphic with more than 256 colors, small fonts
- 150 MB spare hard disk space (after installation)
- CD-ROM drive
- Windows-compatible sound card
- Windows-compatible mouse

Installation

You can install this catalog directly from the CD-ROM as a partial version or full version on your hard disk or in the network.

MICROMASTER 420/430/440 Inverters 0.12 kW to 250 kW Catalog DA 51.2 2007/2008



Supersedes:
Catalog DA 51.2 · 2005/2006

The products in this catalog are also included
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Order No.:

E86060-D4001-A110-C6-7600 (CD-ROM)

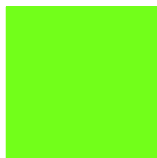
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SIEMENS

Introduction

Siemens
Automation and Drives

0

MICROMASTER

Overview

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2

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7.5 kW to 250 kW

3

MICROMASTER 440
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4

Appendix

A

Siemens Automation and Drives. Welcome

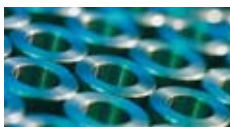
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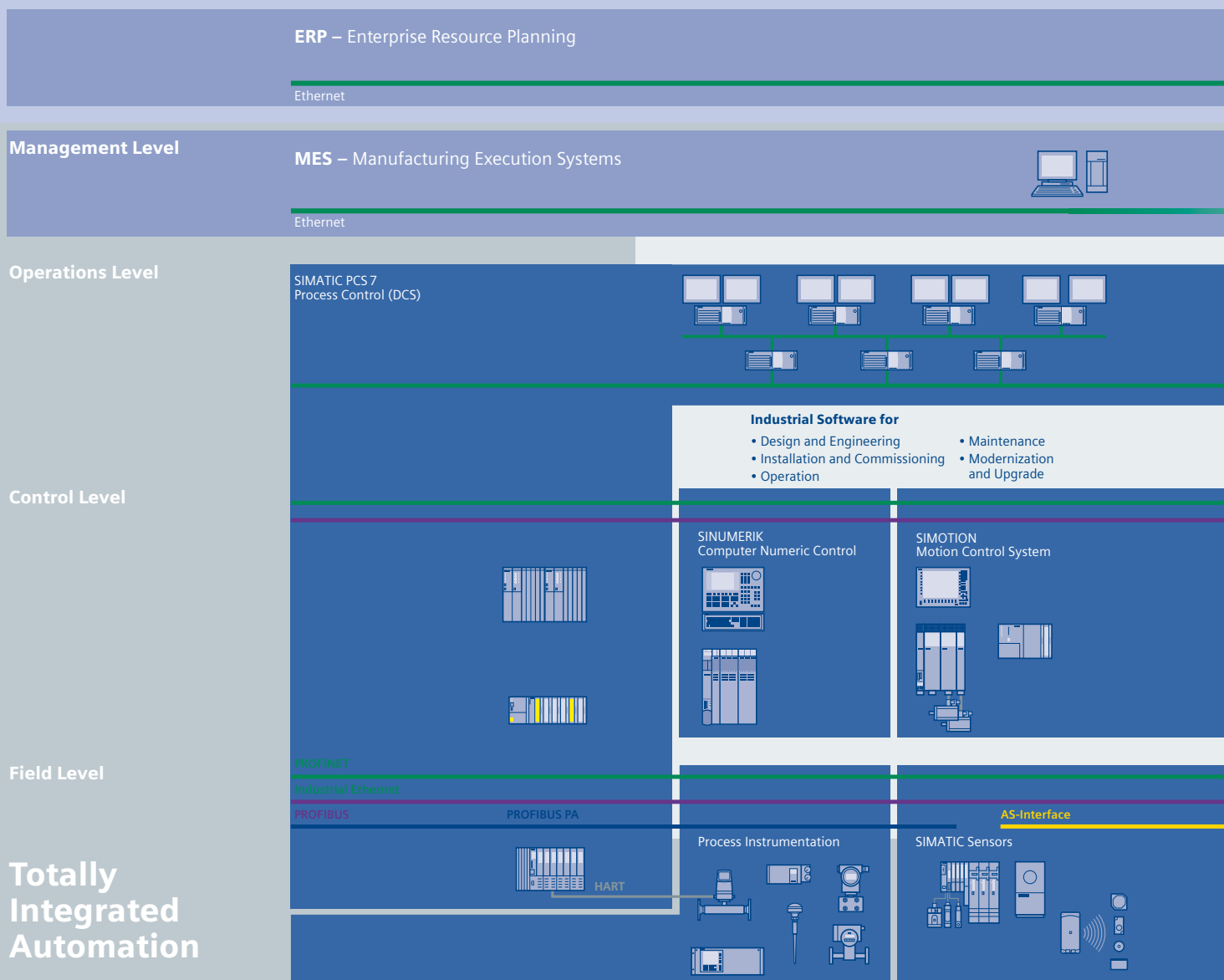




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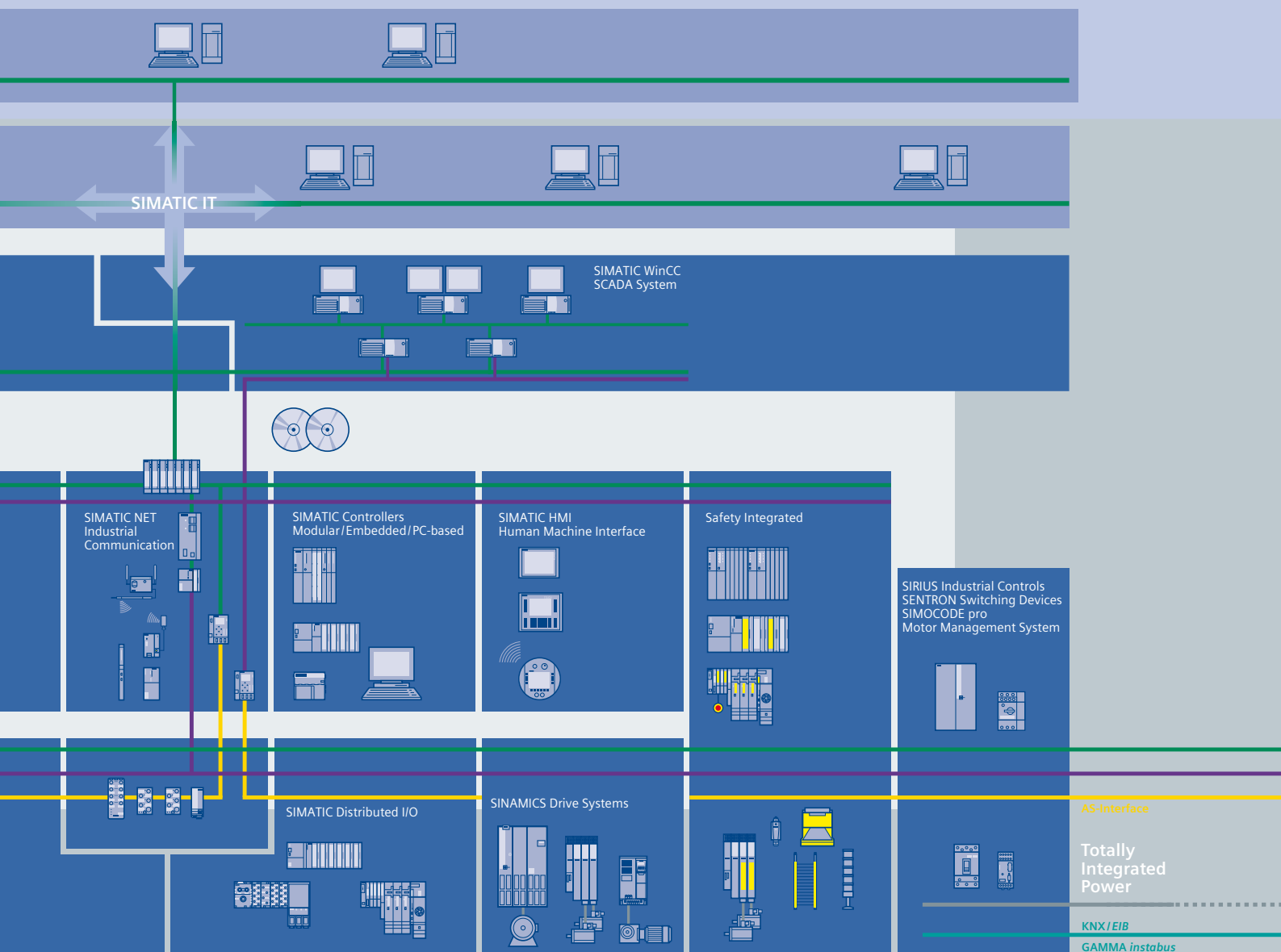
With Totally Integrated Automation (TIA), Siemens is the only manufacturer to offer an integrated range of products and systems for automation in all sectors – from incoming goods to outgoing goods, from the field level through the production control level to connection with the corporate management level.

On the basis of TIA, we implement solutions that are perfectly tailored to your specific requirements and are characterized by a unique level of integration. This integration not only ensures significant reductions in interface costs but also guarantees the highest level of transparency across all levels.




It goes without saying that you profit from Totally Integrated Automation during the entire life cycle of your plants – from the first planning steps, through operation, right up to modernization. Consistent integration in the further development of our products and systems guarantees a high degree of investment security here.

Totally Integrated Automation makes a crucial contribution towards optimizing everything that happens in the plant and thus creates the conditions for a significant increase in productivity.



Protecting the environment and resources. Environmental sustainability



Environmental protection will continue to grow in importance as a result of progressive urbanization and global population growth. These global mega-trends make the careful and sustainable handling of natural resources a central challenge.

We are convinced that every individual - and especially every company - has an ecological responsibility. At Siemens Automation and Drives, we stand by this conviction. Our high environmental protection goals are part of our strict environmental management. We investigate the possible effects of our products and systems on the environment right back at the development stage. We concern ourselves, for example, with the question of how to reduce power consumption in plant operation - and we offer appropriate solutions, such as our energy-saving motors that cut power consumption in industrial manufacturing by up to 40% thanks to their high efficiency levels.

Many of our products and systems comply with the EC Directive RoHS (Restriction of Hazardous Substances). All the relevant Siemens AG sites are, of course, certified in accordance with DIN EN ISO 14001.

Our commitment goes well beyond compliance with the relevant directives and legislation: we are an active driving force behind environmental protection, through further development of environmental management systems, for example, and we are involved in professional associations such as the German Electrical and Electronic Manufacturers Association (ZVEI).

Inverter MICROMASTER



1/2

Selection guide

1/4

Options

1



Overview

Selection guide

	MICROMASTER 410	MICROMASTER 420
Main characteristics	Discontinued product The MICROMASTER 410 is no longer available. The model will be discontinued as of October 1, 2007. The MICROMASTER 410 can then only be ordered as a spare part.	"The universal" for three-phase networks and optional fieldbus interfacing, e.g. for conveyor belts, material transport, pumps, fans and machine tools
Power ranges	–	0.12 kW to 11 kW
Voltage ranges	–	1 AC 200 V to 240 V 3 AC 200 V to 240 V 3 AC 380 V to 480 V
Control methods	–	<ul style="list-style-type: none"> • V/f characteristic • Multipoint characteristic (programmable V/f characteristic) • FCC (flux current control)
Process control	–	Internal PI controller
Inputs	–	3 digital inputs 1 analog input
Outputs	–	1 analog output 1 relay output
Interfacing to automation system	–	The ideal partner for your automation tasks, whether with SIMATIC S7-200, SIMATIC S7-300/400 (TIA) or SIMOTION
Additional features	–	<ul style="list-style-type: none"> • BICO technology • Compound braking for controlled rapid braking
		
	Section 2	

MICROMASTER 430

“The specialist for pumps and fans”

with optimized OP (manual/automatic switchover), matched software functionality and optimized power yield

7.5 kW to 250 kW

3 AC 380 V to 480 V

- V/f characteristic
- Multipoint characteristic (programmable V/f characteristic)
- FCC (flux current control)

Internal PID controller

6 digital inputs
2 analog inputs
1 PTC/KTY input

2 analog outputs
3 relay outputs

The ideal partner for your automation tasks, whether with SIMATIC S7-200, SIMATIC S7-300/400 (TIA) or SIMOTION

- Low-energy mode
- Load torque monitoring (detects dry run of pumps)
- Motor staging
- Bypass mode
- BICO technology



Section 3

MICROMASTER 440

“The all-purpose”

with advanced vector control (with and without encoder feedback) for versatile applications in sectors such as conveying systems, textiles, elevators, hoisting equipment and machine construction

0.12 kW to 250 kW

1 AC 200 V to 240 V
3 AC 200 V to 240 V
3 AC 380 V to 480 V
3 AC 500 V to 600 V

- V/f characteristic
- Multipoint characteristic (programmable V/f characteristic)
- FCC (flux current control)
- Vector control

Internal PID controller (autotuning)

6 digital inputs
2 analog inputs
1 PTC/KTY input

2 analog outputs
3 relay outputs

The ideal partner for your automation tasks, whether with SIMATIC S7-200, SIMATIC S7-300/400 (TIA) or SIMOTION

- 3 selectable drive data kits
- Integrated brake chopper (up to 75 kW)
- Torque control
- BICO technology



Section 4

MICROMASTER 420/430/440

Overview

Options

Various options are available for the MICROMASTER inverters:

- Filters
- Chokes
- Operator panels
- PROFIBUS module
- DeviceNet module
- CANopen module
- Pulse encoder evaluation module
- Gland plates
- Mounting kits, etc.

1) The MICROMASTER 410 is no longer available. The model will be discontinued as of October 1, 2007. The MICROMASTER 410 can then only be ordered as a spare part.

Assignment of operator panels and modules to the inverter ranges

Options	Order No.	MICROMASTER			
		410 ¹⁾	420	430	440
Operator panels					
OP ¹⁾	6SE6400-0SP00-0AA0	●			
BOP	6SE6400-0BP00-0AA0		●		●
BOP-2	6SE6400-0BE00-0AA0			●	
AOP	6SE6400-0AP00-0AA1		●		●
AAOP	6SE6400-0AP00-0AB0		●		●
CAOP	6SE6400-0AP00-0CA0		●		●
Modules					
PROFIBUS	6SE6400-1PB00-0AA0		●	●	●
DeviceNet	6SE6400-1DN00-0AA0		●	●	●
CANopen	6SE6400-1CB00-0AA0		●	●	●
Pulse encoder evaluation	6SE6400-0EN00-0AA0			●	●

Maximum possible configuration:

One pulse encoder evaluation module
+ one communication module + one operator panel

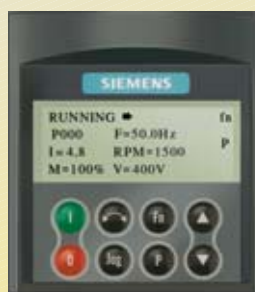
● Possible assignment



BOP in new design
(available soon)



BOP-2 in new design
(available soon)



AOP



AAOP

Operator panels



PROFIBUS



DeviceNet



CANopen



Pulse encoder evaluation

Modules

Inverter MICROMASTER 420



2/2

Description

2/4

Circuit diagrams

2/6

Technical data

2/8

Selection and ordering data

2/9

Options

2/18

Dimension drawings

2



MICROMASTER 420

Description



2

Application

The MICROMASTER 420 inverter is suitable for a variety of variable-speed drive applications. It is especially suitable for applications with pumps, fans and in conveyor systems.

It is the ideal cost-optimized frequency inverter solution. The inverter is especially characterized by its customer-oriented performance and ease-of-use. Its large mains voltage range enables it to be used all over the world.

Design

The MICROMASTER 420 inverter has a modular design. The operator panels and communication modules can be easily exchanged without requiring any tools.

Main characteristics

- Easy, guided start-up
- Modular construction allows maximum configuration flexibility
- Three fully programmable isolated digital inputs
- One analog input (0 V to 10 V, scaleable) or for use as 4th digital input
- One programmable analog output (0 mA to 20 mA)
- One programmable relay output (30 V DC/5 A resistive load; 250 V AC/2A inductive load)
- Low-noise motor operation through high pulse frequency, adjustable (observe derating if necessary)
- Complete protection for motor and inverter.

Options (overview)

- EMC filter, Class A/B
- LC filter
- Line commutating chokes
- Output chokes
- Gland plates
- Basic Operator Panel (BOP) for parameterizing the inverter
- Advanced Operator Panel (AOP) with multi-language plain text display
- Asian Advanced Operator Panel (AAOP) with Chinese and English plain text display
- Cyrillic Advanced Operator Panel (CAOP) with Cyrillic, German and English plain text display
- Communication modules
 - PROFIBUS
 - DeviceNet
 - CANopen
- PC connection kits
- Mounting kits for installing the operator panels in the control cabinet doors
- PC start-up programs executable under Windows 98 and NT/2000/ME/XP Professional
- TIA integration with Drive ES

International standards

- The MICROMASTER 420 inverter complies with the requirements of the EU low-voltage guideline
- The MICROMASTER 420 inverter has the **CE** marking
- acc. to **UL** and **cUL** certified
- c-tick **C**

Note:

See Appendix for standards.

Mechanical features

- Modular design
- Operating temperature
–10 °C to +50 °C
(+14 °F to +122 °F)
- Compact housing as a result of high power density
- Easy cable connection, mains and motor connections are separated for optimum electromagnetic compatibility
- Detachable operator panels
- Screwless control terminals

Performance features

- Latest IGBT technology
- Digital microprocessor control
- Flux Current Control (FCC) for improved dynamic response and optimized motor control
- Linear V/f characteristic
- Quadratic V/f characteristic
- Multipoint characteristic (programmable V/f characteristic)
- Flying restart
- Slip compensation
- Automatic restart following mains failure or fault
- Internal PI controller for simple process control

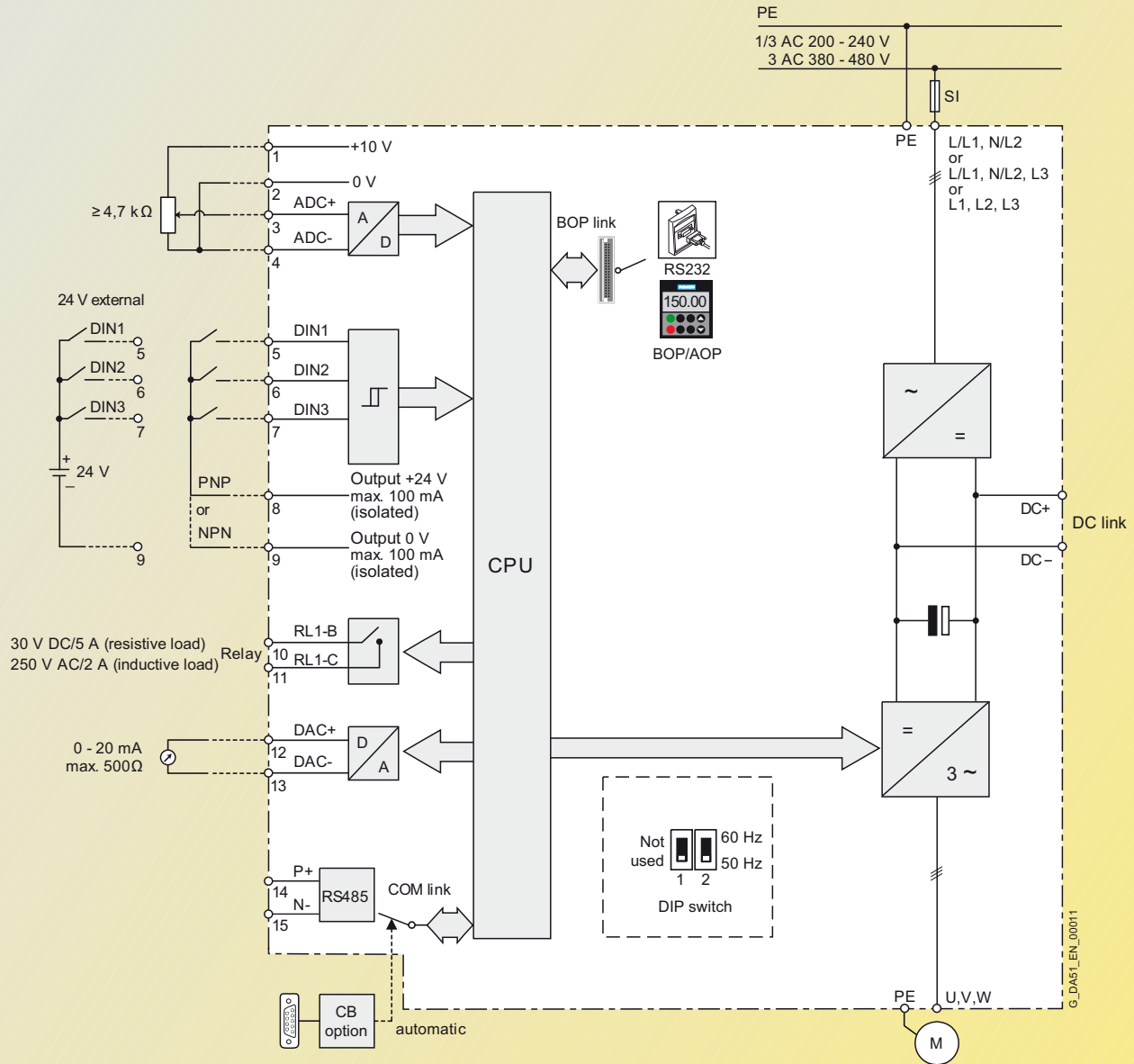
Protection features

- Programmable acceleration/deceleration times from 0 s to 650 s
- Ramp smoothing
- Fast Current Limit (FCL) for trip-free operation
- Fast, repeatable digital input response time
- Fine adjustment using a high-resolution 10-bit analog input
- Compound braking for controlled rapid braking
- Four skip frequencies
- Removable “Y” capacitor for use on IT systems (with non-grounded mains supplies, the “Y” capacitor must be removed and an output choke installed).
- Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 60 s, cycle time 300 s
- Overvoltage/undervoltage protection
- Inverter overtemperature protection
- Motor protection using PTC via digital input (possible with supplementary circuit)
- Earth fault protection
- Short-circuit protection
- I^2t motor thermal protection
- Locked motor protection
- Stall prevention
- Parameter interlock

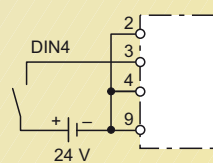
MICROMASTER 420

Circuit diagrams

General circuit diagram

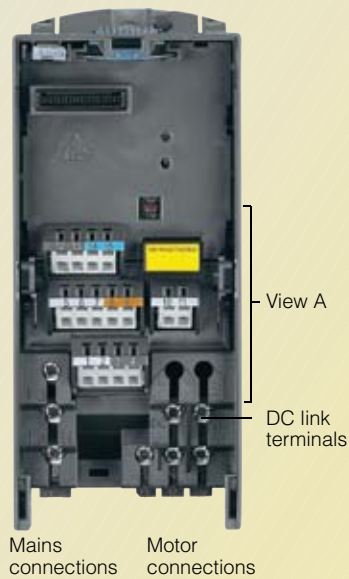


The analog input can be used as an additional digital input (DIN4)

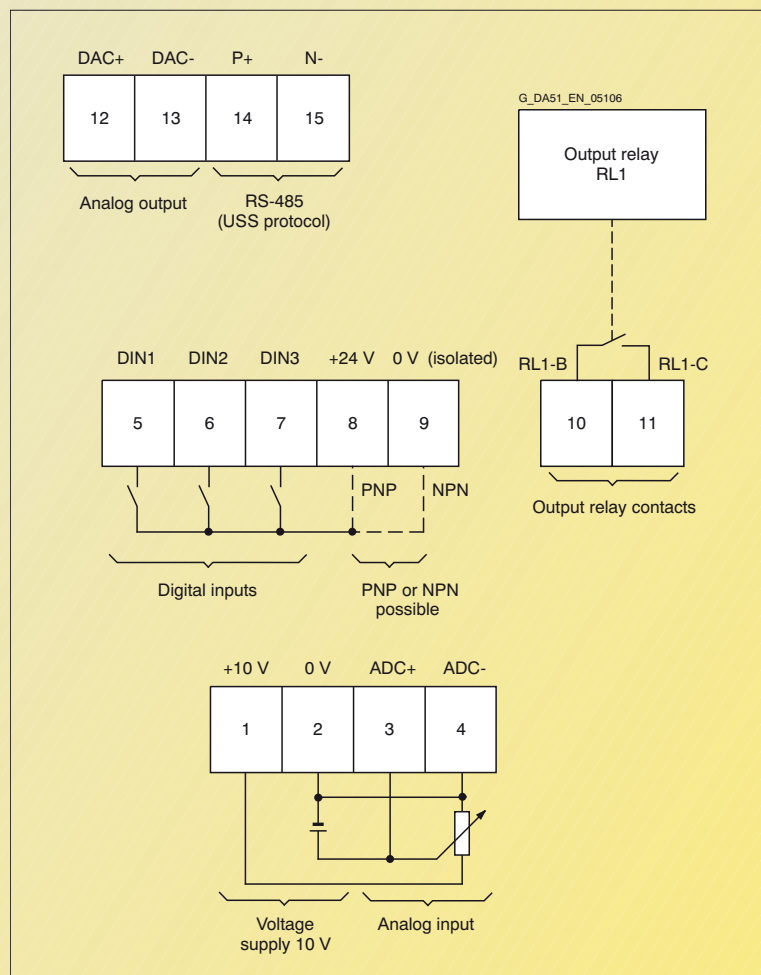


Terminal connection diagram

Example frame size A



View A



MICROMASTER 420

Technical data

MICROMASTER 420 inverter

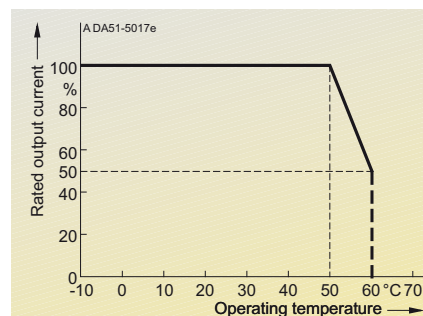
Mains voltage and power ranges	1 AC 200 V to 240 V \pm 10 % 3 AC 200 V to 240 V \pm 10 % 3 AC 380 V to 480 V \pm 10 %	0.12 kW to 3 kW 0.12 kW to 5.5 kW 0.37 kW to 11 kW		
Power frequency	47 Hz to 63 Hz			
Output frequency	0 Hz to 650 Hz (Due to legal restrictions a limitation to 550 Hz is under preparation)			
Power factor	\geq 0.95			
Inverter efficiency	96 % to 97 % (Further information is available on the Internet at: http://support.automation.siemens.com/WW/view/en/22978972)			
Overload capability	Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 60 s, cycle time 300 s			
Inrush current	Less than rated input current			
Control method	Linear V/f-characteristic; quadratic V/f characteristic; multipoint characteristic (programmable V/f characteristic); flux current control (FCC)			
Pulse frequency	16 kHz (standard with 1/3 AC 230 V) 4 kHz (standard with 3 AC 400 V) 2 kHz to 16 kHz (in 2 kHz steps)			
Fixed frequencies	7, programmable			
Skip frequency ranges	4, programmable			
Setpoint resolution	0.01 Hz digital 0.01 Hz serial 10 bit analog			
Digital inputs	3 fully programmable isolated digital inputs; switchable PNP/NPN			
Analog input	1, for setpoint or PI controller (0 V to 10 V, scaleable or for use as 4th digital input)			
Relay outputs	1, programmable, 30 V DC/5 A (resistive load); 250 V AC/2A (inductive load)			
Analog output	1, programmable (0 mA to 20 mA)			
Serial interfaces	RS-485, optional RS-232			
Motor cable lengths	without output choke max. 50 m (shielded) without output choke max. 100 m (unshielded) see variant dependent options			
Electromagnetic compatibility	Inverter available with internal EMC filter Class A; available as options are EMC filters to EN 55 011, Class A or Class B			
Braking	DC braking, compound braking			
Degree of protection	IP20			
Operating temperature	-10 °C to +50 °C (+14 °F to +122 °F)			
Storage temperature	-40 °C to +70 °C (-40 °F to +158 °F)			
Relative humidity	95 % (non-condensing)			
Installation altitude	Up to 1000 m above sea level without derating			
Standard SCCR (Short Circuit Current Rating) ¹⁾	10 kA			
Protection features for	<ul style="list-style-type: none"> • Undervoltage • Overvoltage • Overload • Earth faults • Short circuit • Stall prevention • Locked motor protection • Motor overtemperature • Inverter overtemperature • Parameter interlock 			
Compliance with standards	UL, cUL, CE, c-tick			
CE marking	Conformity with low-voltage directive 73/23/EEC			
Cooling-air volumetric flow required, dimensions and weights (without options)	Frame size (FS)	Cooling-air volumetric flow required (l/s)/(CFM)	H x W x D (mm)	Weight, approx. (kg)
	A	4.8/10.2	173 x 73 x 149	1.0
	B	24/51	202 x 149 x 172	3.3
	C	54.9/116.3	245 x 185 x 195	5.0

CFM: Cubic Feet per Minute

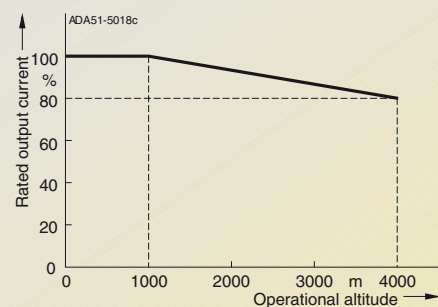
1) Applies to industrial control cabinet installations to NEC article 409/UL 508A.

Derating data**Pulse frequency**

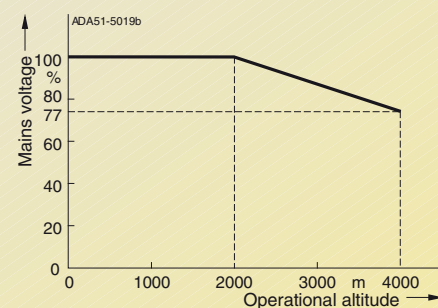
Output (for 3 AC 400 V) kW	Rated output current in A for a pulse frequency of						
	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz	14 kHz	16 kHz
0.37	1.2	1.2	1.2	1.2	1.2	1.2	1.1
0.55	1.6	1.6	1.6	1.6	1.6	1.6	1.1
0.75	2.1	2.1	2.1	2.1	1.6	1.6	1.1
1.1	3.0	3.0	2.7	2.7	1.6	1.6	1.1
1.5	4.0	4.0	2.7	2.7	1.6	1.6	1.1
2.2	5.9	5.9	5.1	5.1	3.6	3.6	2.6
3.0	7.7	7.7	5.1	5.1	3.6	3.6	2.6
4.0	10.2	10.2	6.7	6.7	4.8	4.8	3.6
5.5	13.2	13.2	13.2	13.2	9.6	9.6	7.5
7.5	19.0	18.4	13.2	13.2	9.6	9.6	7.5
11	26.0	26.0	17.9	17.9	13.5	13.5	10.4

Operating temperature**Installation altitude above sea level**

Permissible output current
in % of the rated output current



Permissible mains voltage
in % of the max. possible mains voltage



MICROMASTER 420

Selection and ordering data

MICROMASTER 420 inverter

Output		Rated input current ¹⁾	Rated output current	Frame size	Order No.	
kW	hp	A	A	(FS)	MICROMASTER 420 without filter ³⁾	MICROMASTER 420 with internal filter Class A ²⁾
Mains operating voltage 1 AC 200 V to 240 V						
0.12	0.16	1.8	0.9	A	6SE6420-2UC11-2AA1	6SE6420-2AB11-2AA1
0.25	0.33	3.2	1.7	A	6SE6420-2UC12-5AA1	6SE6420-2AB12-5AA1
0.37	0.50	4.6	2.3	A	6SE6420-2UC13-7AA1	6SE6420-2AB13-7AA1
0.55	0.75	6.2	3.0	A	6SE6420-2UC15-5AA1	6SE6420-2AB15-5AA1
0.75	1.0	8.2	3.9	A	6SE6420-2UC17-5AA1	6SE6420-2AB17-5AA1
1.1	1.5	11.0	5.5	B	6SE6420-2UC21-1BA1	6SE6420-2AB21-1BA1
1.5	2.0	14.4	7.4	B	6SE6420-2UC21-5BA1	6SE6420-2AB21-5BA1
2.2	3.0	20.2	10.4	B	6SE6420-2UC22-2BA1	6SE6420-2AB22-2BA1
3.0	4.0	35.5	13.6	C	6SE6420-2UC23-0CA1	6SE6420-2AB23-0CA1
Mains operating voltage 3 AC 200 V to 240 V						
0.12	0.16	1.1	0.9	A	6SE6420-2UC11-2AA1	–
0.25	0.33	1.9	1.7	A	6SE6420-2UC12-5AA1	–
0.37	0.50	2.7	2.3	A	6SE6420-2UC13-7AA1	–
0.55	0.75	3.6	3.0	A	6SE6420-2UC15-5AA1	–
0.75	1.0	4.7	3.9	A	6SE6420-2UC17-5AA1	–
1.1	1.5	6.4	5.5	B	6SE6420-2UC21-1BA1	–
1.5	2.0	8.3	7.4	B	6SE6420-2UC21-5BA1	–
2.2	3.0	11.7	10.4	B	6SE6420-2UC22-2BA1	–
3.0	4.0	15.6	13.6	C	6SE6420-2UC23-0CA1	6SE6420-2AC23-0CA1
4.0	5.0	19.7	17.5	C	6SE6420-2UC24-0CA1	6SE6420-2AC24-0CA1
5.5	7.5	26.5	22.0	C	6SE6420-2UC25-5CA1	6SE6420-2AC25-5CA1
Mains operating voltage 3 AC 380 V to 480 V						
0.37	0.50	2.2	1.2	A	6SE6420-2UD13-7AA1	–
0.55	0.75	2.8	1.6	A	6SE6420-2UD15-5AA1	–
0.75	1.0	3.7	2.1	A	6SE6420-2UD17-5AA1	–
1.1	1.5	4.9	3.0	A	6SE6420-2UD21-1AA1	–
1.5	2.0	5.9	4.0	A	6SE6420-2UD21-5AA1	–
2.2	3.0	7.5	5.9	B	6SE6420-2UD22-2BA1	6SE6420-2AD22-2BA1
3.0	4.0	10.0	7.7	B	6SE6420-2UD23-0BA1	6SE6420-2AD23-0BA1
4.0	5.0	12.8	10.2	B	6SE6420-2UD24-0BA1	6SE6420-2AD24-0BA1
5.5	7.5	15.6	13.2	C	6SE6420-2UD25-5CA1	6SE6420-2AD25-5CA1
7.5	10.0	22.0	19.0	C	6SE6420-2UD27-5CA1	6SE6420-2AD27-5CA1
11	15.0	32.3	26.0	C	6SE6420-2UD31-1CA1	6SE6420-2AD31-1CA1



See Appendix for note on ordering.

All MICROMASTER 420 inverters are supplied with a Status Display Panel (SDP). A BOP, AOP or other options have to be ordered separately (see Pages 2/12 to 2/16).

Motors for MICROMASTER 420

Catalog D 81.1 contains selection and ordering data for motors which are particularly suitable for operation with the MICROMASTER 420 inverters (see Appendix for overview).

This catalog is suitable for IEC motors. For motors according to US standards (NEMA) please refer to Catalog D 81.2 U.S./Canada (see Appendix for overview) and to: <http://www.sea.siemens.com/motors>

1) Supplementary conditions:
Input current at rated operating point, applicable at short-circuit voltage of the supply $U_{sc} = 2\%$ with reference to the

inverter rated power and rated mains voltage of 240 V or 400 V without a line commutating choke.

2) Use of MICROMASTER inverters with internal filter is not permissible on non-grounded (IT) mains supplies.

3) Acc. to EMC EN 61800-3 generally suited to heavy industrial applications. For details please refer to Appendix on page A/4.

Overview**EMC filter, Class A**

Filter for inverters without an internal filter for

- 3 AC 200 V to 240 V, frame sizes A and B
- 3 AC 380 V to 480 V, frame size A.

All other inverters can be supplied with an internal Class A filter.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

EMC filter, Class B

Filter for inverters without an internal filter for

- 3 AC 200 V to 240 V, frame sizes A and B
- 3 AC 380 V to 480 V, frame size A.

With this filter, the inverter complies with the emission standard EN 55 011, Class B for conducted interference emissions.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

Additional EMC filter, Class B

Available for inverters with an internal Class A EMC filter.

With this filter, the inverter complies with the emission standard EN 55 011, Class B for conducted interference emissions.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

Filter Class B with low leakage currents

EMC filter for 1 AC 200 V to 240 V inverters, frame sizes A and B, without an internal EMC filter Class A.

With this filter, the inverter complies with the emission standard EN 55 011, Class B for conducted interference emissions. The leakage currents are reduced to < 3.5 mA.

The requirements are fulfilled using shielded cables with a max. length of 5 m.

Leakage currents:

The leakage currents of the inverters with/without filter (internal/external) may exceed 30 mA. Typical values in practice are between 10 mA and 50 mA. The exact values depend on the design, environment and cable lengths. Interference-free operation with residual current operated devices with a trigger value of 30 mA cannot be guaranteed. However, operation with residual current circuit-breakers with a trigger value of 300 mA is possible. Please refer to the Instruction Manual for details.

LC filter

The LC filter limits the rate of rise of voltage and the capacitive charge/discharge currents which usually occur with inverter operation. This means that much longer shielded motor cables are possible when using LC filters and the service life of the motor achieves values similar to those with direct mains operation. Use of an output choke isn't required with that.

Please note when using LC filters:

- Only V/f, FCC control permissible
- Please observe the derating of 15% when selecting the appropriate inverter
- Operation only permissible with 4 kHz pulse frequency
- The output frequency is limited to 150 Hz
- Operation and commissioning only with connected motor as the LC filter is not idling-proof!

The LC filters can be used for all MICROMASTER 420 inverters of frame sizes A to C.

Line commutating choke

Line commutating chokes are used to smooth voltage peaks or to bridge commutating dips. In addition, line commutating chokes reduce the effects of harmonics on the inverter and the power supply. If the line impedance is < 1 %, a line commutating choke must be used in order to reduce the current peaks.

In line with EN 61 000-3-2 regulations "Limits for harmonic currents with device input current ≤ 16 A per phase", there are special aspects for drives with 250 W to 550 W and 230 V single-phase supplies which can be used in non-industrial applications (1st environment).

For devices with 250 W and 370 W, it is necessary either to fit the recommended input chokes or to apply to the power utility company for authorization to connect the devices to the public power supply. No limits are currently defined in the EN 61 000-3-2 standard for professionally used devices with a connected load > 1 kW which means that the inverters with an output power ≥ 0.75 kW comply with the EN 61 000-3-2 standard.

However, in accordance with the regulations of EN 61000-3-12 "Limits for harmonic currents > 16 A and ≤ 75 A per phase" an approval is necessary from the power supplier for drives that are intended to be connected to the public low-voltage network. Please refer to the Operating Instructions for the values of the harmonic currents.

Output choke

Output chokes can be supplied for reducing the capacitive currents and dV/dt in the case of motor cables > 50 m (shielded) or > 100 m (unshielded).

For max. permissible cable lengths, see Technical Data.

Gland plate

The gland plate facilitates the shield connection of power and control cables and ensures optimum EMC performance.

MICROMASTER 420

Options

Variant dependent options

Technical data

LC filter

Mains voltage		3 AC 380 V to 480 V
Current (at 40 °C/50 °C)	for frame size A for frame size B for frame size C	4.5 A/ 4.1 A 11.2 A/10.2 A 32.6 A/29.7 A
Limiting of motor overvoltage		≤ 1078 V
dV/dt limiting		≤ 500 V/μs
Pulse frequency		4 kHz
Max. motor frequency		150 Hz
Max. permissible motor cable lengths	shielded unshielded	200 m 300 m
Insulation strength		Overvoltage category III to VDE 0110
Electromagnetic compatibility		Up to 200 m motor cable length with emissions to Class A according to EN 55 011 in conjunction with filtered inverters and unshielded cables
Conformity		CE according to the low-voltage directive 73/23/EEC
Approvals		UL available soon
Strain resistance		EN 60 068-2-31
Humidity		95 % humidity, non-condensing
Degree of protection		IP20 (to EN 60529)
Insulation class		H (180 °C)
Permissible temperature	Operation Storage	–10 °C to +40 °C (+14 °F to +104 °F) to +50 °C (to +122 °F) –25 °C to +70 °C (–13 °F to +158 °F) 100 % P _n 80 % P _n
Installation altitude	up to 2000 m 2000 to 4000 m	100 % P _n 62.5 % P _n
Mounting position		Footprint or suspended
Free space	Top Bottom Side	100 mm 100 mm 100 mm
Connection system	Input, litz wire or terminal Output, terminals	1U1, 1V1, 1W1 1U2, 1V2, 1W2
Torque for power conductor connections		1.5 Nm to 1.8 Nm
Weight, approx.	for frame size A for frame size B for frame size C	7 kg 11 kg 29 kg

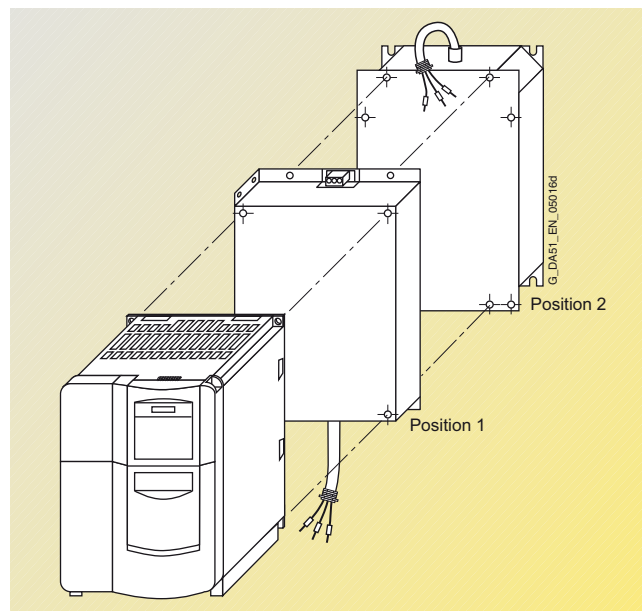
Max. permissible cable lengths from the motor to the inverter when using output chokes

The following table shows the maximum permissible cable lengths from the motor to the inverter when using output chokes.

Frame size	Output choke	Max. permissible motor cable lengths (shielded/unshielded) for a mains voltage of		
(FS)	Type	200 V to 240 V ± 10 %	380 V to 400 V ± 10 %	401 V to 480 V ± 10 %
A	6SE6400-3TC00-4AD3	200 m/300 m	–	–
A	6SE6400-3TC00-4AD2	200 m/300 m	150 m/225 m	100 m/150 m
B	6SE6400-3TC01-0BD3	200 m/300 m	150 m/225 m	100 m/150 m
C	6SE6400-3TC03-2CD3	200 m/300 m	200 m/300 m	100 m/150 m

Design**General installation instructions**

- A maximum of two footprint components plus inverter are permissible.
- If an LC filter is used, it must be mounted directly on the wall of the control cabinet due to weight reasons. If an LC filter of frame size C is used, therefore, only one footprint component is permissible. If a line choke and LC filter are used, the line choke must be located on the left of the inverter. Required distance between line choke and inverter: 75 mm.
- The EMC filter must be mounted directly below the frequency inverter if possible.
- If mounted on the side, the line-side components are to be mounted to the left of the frequency inverter whereas the output-side components are to be mounted to the right of the frequency inverter.



Example of installation with frequency inverter, EMC filter (position 1) and line choke (position 2)

Availability of the options as footprint components

	Frame size		
	A	B	C
Line commutating choke	✓	✓	✓
EMC filter	✓	✓	✓
LC filter	✓	✓	✓
Output choke	✓	✓	✓

Recommended combinations of inverters and options

Frequency inverter Frame size	Footprint		Mounted on side	
	Position 1	Position 2	To the left of the inverter (for line-side components)	To the right of the inverter (for output-side components)
A and B	EMC filter	Line commutating choke	–	Output choke
	EMC filter <u>or</u> Line commutating choke	Output choke <u>or</u> LC filter	–	–
C	EMC filter	Line commutating choke	–	Output choke
	EMC filter <u>or</u> Line commutating choke	Output choke	–	–
	LC filter	–	EMC filter <u>and/or</u> Line commutating choke	–

MICROMASTER 420

Options

Variant dependent options

Selection and ordering data

The options listed here (filters, chokes, gland plates, fuses, and circuit-breakers) must be selected to match the inverter.

The inverter and the associated options have the same voltage ratings. Alternatively fuses and circuit-breakers can be

provided. Both provide short circuit protection of the inverter supply line and the inverter. A semiconductor protection of

the inverter with the suggested 3NA... fuses and the 3RV... circuit-breakers is not envisaged.

Mains voltage	Output		Inverter without filter	Order No. of the options		
	kW	hp		EMC filter Class A	EMC filter Class B	Additional EMC filter, Class B
1 AC 200 V to 240 V	0.12	0.16	6SE6420-2UC11-2AA1	–	6SE6400-2FL01-0AB0 with low leakage currents	–
	0.25	0.33	6SE6420-2UC12-5AA1	–		–
	0.37	0.50	6SE6420-2UC13-7AA1	–		–
	0.55	0.75	6SE6420-2UC15-5AA1	–		–
	0.75	1.0	6SE6420-2UC17-5AA1	–		–
	1.1	1.5	6SE6420-2UC21-1BA1	–	6SE6400-2FL02-6BB0 with low leakage currents	–
	1.5	2.0	6SE6420-2UC21-5BA1	–		–
	2.2	3.0	6SE6420-2UC22-2BA1	–		–
	3.0	4.0	6SE6420-2UC23-0CA1	–		–
3 AC 200 V to 240 V	0.12	0.16	6SE6420-2UC11-2AA1	6SE6400-2FA00-6AD0	6SE6400-2FB00-6AD0	–
	0.25	0.33	6SE6420-2UC12-5AA1			–
	0.37	0.50	6SE6420-2UC13-7AA1			–
	0.55	0.75	6SE6420-2UC15-5AA1			–
	0.75	1.0	6SE6420-2UC17-5AA1			–
	1.1	1.5	6SE6420-2UC21-1BA1	6SE6400-2FA01-4BC0	6SE6400-2FB01-4BC0	–
	1.5	2.0	6SE6420-2UC21-5BA1			–
	2.2	3.0	6SE6420-2UC22-2BA1	–	–	–
	3.0	4.0	6SE6420-2UC23-0CA1	–	–	–
	4.0	5.0	6SE6420-2UC24-0CA1	–	–	–
	5.5	7.5	6SE6420-2UC25-5CA1	–	–	–
3 AC 380 V to 480 V	0.37	0.50	6SE6420-2UD13-7AA1	6SE6400-2FA00-6AD0	6SE6400-2FB00-6AD0	–
	0.55	0.75	6SE6420-2UD15-5AA1			–
	0.75	1.0	6SE6420-2UD17-5AA1			–
	1.1	1.5	6SE6420-2UD21-1AA1			–
	1.5	2.0	6SE6420-2UD21-5AA1			–
	2.2	3.0	6SE6420-2UD22-2BA1	–	–	–
	3.0	4.0	6SE6420-2UD23-0BA1	–	–	–
	4.0	5.0	6SE6420-2UD24-0BA1	–	–	–
	5.5	7.5	6SE6420-2UD25-5CA1	–	–	–
	7.5	10.0	6SE6420-2UD27-5CA1	–	–	–
	11	15.0	6SE6420-2UD31-1CA1	–	–	–
			Inverter with internal filter Class A			
1 AC 200 V to 240 V	0.12	0.16	6SE6420-2AB11-2AA1	–	–	6SE6400-2FS01-0AB0
	0.25	0.33	6SE6420-2AB12-5AA1	–	–	
	0.37	0.50	6SE6420-2AB13-7AA1	–	–	
	0.55	0.75	6SE6420-2AB15-5AA1	–	–	
	0.75	1.0	6SE6420-2AB17-5AA1	–	–	
	1.1	1.5	6SE6420-2AB21-1BA1	–	–	6SE6400-2FS02-6BB0
	1.5	2.0	6SE6420-2AB21-5BA1	–	–	
	2.2	3.0	6SE6420-2AB22-2BA1	–	–	
	3.0	4.0	6SE6420-2AB23-0CA1	–	–	6SE6400-2FS03-5CB0
3 AC 200 V to 240 V	3.0	4.0	6SE6420-2AC23-0CA1	–	–	6SE6400-2FS03-8CD0
	4.0	5.0	6SE6420-2AC24-0CA1	–	–	
	5.5	7.5	6SE6420-2AC25-5CA1	–	–	
3 AC 380 V to 480 V	2.2	3.0	6SE6420-2AD22-2BA1	–	–	6SE6400-2FS01-6BD0
	3.0	4.0	6SE6420-2AD23-0BA1	–	–	
	4.0	5.0	6SE6420-2AD24-0BA1	–	–	
	5.5	7.5	6SE6420-2AD25-5CA1	–	–	6SE6400-2FS03-8CD0
	7.5	10.0	6SE6420-2AD27-5CA1	–	–	
	11	15.0	6SE6420-2AD31-1CA1	–	–	

Selection and ordering data (continued)

All options are certified to
 ☉, except fuses.
 The fuses of Type 3NA3 as
 well as circuit-breakers of

type 3RV are recommended
 for Europe.

Additional information on
 the listed fuses and circuit-
 breakers can be found in
 Catalogs LV 10 and IC 10.

Use in America requires ☉-
 listed fuses Class J.

Mains voltage	Output		Inverter without filter	Order No. of the options		
	kW	hp		Line commutating choke	LC filter	Output choke
1 AC 200 V to 240 V	0.12	0.16	6SE6420-2UC11-2AA1	6SE6400-3CC00-4AB3	–	6SE6400-3TC00-4AD3
	0.25	0.33	6SE6420-2UC12-5AA1	–	–	–
	0.37	0.50	6SE6420-2UC13-7AA1	6SE6400-3CC01-0AB3	–	–
	0.55	0.75	6SE6420-2UC15-5AA1	–	–	–
	0.75	1.0	6SE6420-2UC17-5AA1	–	–	–
	1.1	1.5	6SE6420-2UC21-1BA1	6SE6400-3CC02-6BB3	–	6SE6400-3TC01-0BD3
	1.5	2.0	6SE6420-2UC21-5BA1	–	–	–
	2.2	3.0	6SE6420-2UC22-2BA1	–	–	–
	3.0	4.0	6SE6420-2UC23-0CA1	6SE6400-3CC03-5CB3	–	6SE6400-3TC03-2CD3
3 AC 200 V to 240 V	0.12	0.16	6SE6420-2UC11-2AA1	6SE6400-3CC00-3AC3	–	6SE6400-3TC00-4AD3
	0.25	0.33	6SE6420-2UC12-5AA1	–	–	–
	0.37	0.50	6SE6420-2UC13-7AA1	6SE6400-3CC00-5AC3	–	–
	0.55	0.75	6SE6420-2UC15-5AA1	–	–	–
	0.75	1.0	6SE6420-2UC17-5AA1	–	–	–
	1.1	1.5	6SE6420-2UC21-1BA1	6SE6400-3CC00-8BC3	–	6SE6400-3TC01-0BD3
	1.5	2.0	6SE6420-2UC21-5BA1	6SE6400-3CC01-4BD3	–	–
	2.2	3.0	6SE6420-2UC22-2BA1	–	–	–
	3.0	4.0	6SE6420-2UC23-0CA1	6SE6400-3CC01-7CC3	–	6SE6400-3TC03-2CD3
3 AC 200 V to 240 V	4.0	5.0	6SE6420-2UC24-0CA1	6SE6400-3CC03-5CD3	–	–
	5.5	7.5	6SE6420-2UC25-5CA1	–	–	–
3 AC 380 V to 480 V	0.37	0.50	6SE6420-2UD13-7AA1	6SE6400-3CC00-2AD3	6SE6400-3TD00-4AD0	6SE6400-3TC00-4AD2
	0.55	0.75	6SE6420-2UD15-5AA1	–	–	–
	0.75	1.0	6SE6420-2UD17-5AA1	6SE6400-3CC00-4AD3	–	–
	1.1	1.5	6SE6420-2UD21-1AA1	–	–	–
	1.5	2.0	6SE6420-2UD21-5AA1	6SE6400-3CC00-6AD3	–	–
	2.2	3.0	6SE6420-2UD22-2BA1	6SE6400-3CC01-0BD3	6SE6400-3TD01-0BD0	6SE6400-3TC01-0BD3
	3.0	4.0	6SE6420-2UD23-0BA1	–	–	–
	4.0	5.0	6SE6420-2UD24-0BA1	6SE6400-3CC01-4BD3	–	–
	5.5	7.5	6SE6420-2UD25-5CA1	6SE6400-3CC02-2CD3	6SE6400-3TD03-2CD0	6SE6400-3TC03-2CD3
3 AC 380 V to 480 V	7.5	10.0	6SE6420-2UD27-5CA1	–	–	–
	11	15.0	6SE6420-2UD31-1CA1	6SE6400-3CC03-5CD3	–	–
			Inverter with internal filter Class A			
1 AC 200 V to 240 V	0.12	0.16	6SE6420-2AB11-2AA1	6SE6400-3CC00-4AB3	–	6SE6400-3TC00-4AD3
	0.25	0.33	6SE6420-2AB12-5AA1	–	–	–
	0.37	0.50	6SE6420-2AB13-7AA1	6SE6400-3CC01-0AB3	–	–
	0.55	0.75	6SE6420-2AB15-5AA1	–	–	–
	0.75	1.0	6SE6420-2AB17-5AA1	–	–	–
	1.1	1.5	6SE6420-2AB21-1BA1	6SE6400-3CC02-6BB3	–	6SE6400-3TC01-0BD3
	1.5	2.0	6SE6420-2AB21-5BA1	–	–	–
	2.2	3.0	6SE6420-2AB22-2BA1	–	–	–
	3.0	4.0	6SE6420-2AB23-0CA1	6SE6400-3CC03-5CB3	–	6SE6400-3TC03-2CD3
3 AC 200 V to 240 V	3.0	4.0	6SE6420-2AC23-0CA1	6SE6400-3CC01-7CC3	–	6SE6400-3TC03-2CD3
	4.0	5.0	6SE6420-2AC24-0CA1	6SE6400-3CC03-5CD3	–	–
	5.5	7.5	6SE6420-2AC25-5CA1	–	–	–
3 AC 380 V to 480 V	2.2	3.0	6SE6420-2AD22-2BA1	6SE6400-3CC01-0BD3	6SE6400-3TD01-0BD0	6SE6400-3TC01-0BD3
	3.0	4.0	6SE6420-2AD23-0BA1	–	–	–
	4.0	5.0	6SE6420-2AD24-0BA1	6SE6400-3CC01-4BD3	–	–
	5.5	7.5	6SE6420-2AD25-5CA1	6SE6400-3CC02-2CD3	6SE6400-3TD03-2CD0	6SE6400-3TC03-2CD3
	7.5	10.0	6SE6420-2AD27-5CA1	–	–	–
	11	15.0	6SE6420-2AD31-1CA1	6SE6400-3CC03-5CD3	–	–

MICROMASTER 420

Options

Variant dependent options

Selection and ordering data (continued)

Mains voltage	Output		Inverter without filter	Order No. of the options		
	kW	hp		Gland plate	Fuse (see Catalog LV 10)	Circuit-breaker (see Catalog IC 10)
1 AC 200 V to 240 V	0.12	0.16	6SE6420-2UC11-2AA1	6SE6400-0GP00-0AA0	3NA3803	3RV2011-1DA10
	0.25	0.33	6SE6420-2UC12-5AA1			3RV2011-1GA10
	0.37	0.50	6SE6420-2UC13-7AA1			3RV2011-1HA10
	0.55	0.75	6SE6420-2UC15-5AA1			3RV2011-1JA10
	0.75	1.0	6SE6420-2UC17-5AA1	6SE6400-0GP00-0BA0	3NA3805	3RV2021-4AA10
	1.1	1.5	6SE6420-2UC21-1BA1		3NA3807	3RV2021-4BA10
	1.5	2.0	6SE6420-2UC21-5BA1			3RV2021-4DA10
	2.2	3.0	6SE6420-2UC22-2BA1		3NA3812	3RV1031-4FA10
	3.0	4.0	6SE6420-2UC23-0CA1	6SE6400-0GP00-0CA0	3NA3817	3RV1031-4HA10
3 AC 200 V to 240 V	0.12	0.16	6SE6420-2UC11-2AA1	6SE6400-0GP00-0AA0	3NA3803	3RV2011-1AA10
	0.25	0.33	6SE6420-2UC12-5AA1			3RV2011-1DA10
	0.37	0.50	6SE6420-2UC13-7AA1			3RV2011-1EA10
	0.55	0.75	6SE6420-2UC15-5AA1			3RV2011-1GA10
	0.75	1.0	6SE6420-2UC17-5AA1	6SE6400-0GP00-0BA0	3NA3805	3RV2011-1HA10
	1.1	1.5	6SE6420-2UC21-1BA1			3RV2011-1KA10
	1.5	2.0	6SE6420-2UC21-5BA1			3RV2021-4AA10
	2.2	3.0	6SE6420-2UC22-2BA1		3NA3807	3RV2021-4BA10
	3.0	4.0	6SE6420-2UC23-0CA1	6SE6400-0GP00-0CA0	3NA3810	3RV2021-4CA10
	4.0	5.0	6SE6420-2UC24-0CA1		3NA3812	3RV1031-4EA10
	5.5	7.5	6SE6420-2UC25-5CA1		3NA3814	3RV1031-4FA10
3 AC 380 V to 480 V	0.37	0.50	6SE6420-2UD13-7AA1	6SE6400-0GP00-0AA0	3NA3803	3RV2011-1CA10
	0.55	0.75	6SE6420-2UD15-5AA1			3RV2011-1DA10
	0.75	1.0	6SE6420-2UD17-5AA1			3RV2011-1EA10
	1.1	1.5	6SE6420-2UD21-1AA1			3RV2011-1GA10
	1.5	2.0	6SE6420-2UD21-5AA1	6SE6400-0GP00-0BA0	3NA3805	3RV2011-1HA10
	2.2	3.0	6SE6420-2UD22-2BA1			3RV2011-1JA10
	3.0	4.0	6SE6420-2UD23-0BA1			3RV2011-1KA10
	4.0	5.0	6SE6420-2UD24-0BA1		3NA3807	3RV2021-4AA10
	5.5	7.5	6SE6420-2UD25-5CA1	6SE6400-0GP00-0CA0	3NA3810	3RV2021-4CA10
	7.5	10.0	6SE6420-2UD27-5CA1			3RV1031-4EA10
	11	15.0	6SE6420-2UD31-1CA1		3NA3814	3RV1031-4GA10
			Inverter with internal filter Class A			
1 AC 200 V to 240 V	0.12	0.16	6SE6420-2AB11-2AA1	6SE6400-0GP00-0AA0	3NA3803	3RV2011-1DA10
	0.25	0.33	6SE6420-2AB12-5AA1			3RV2011-1GA10
	0.37	0.50	6SE6420-2AB13-7AA1			3RV2011-1HA10
	0.55	0.75	6SE6420-2AB15-5AA1			3RV2011-1JA10
	0.75	1.0	6SE6420-2AB17-5AA1	6SE6400-0GP00-0BA0	3NA3805	3RV2021-4AA10
	1.1	1.5	6SE6420-2AB21-1BA1		3NA3807	3RV2021-4BA10
	1.5	2.0	6SE6420-2AB21-5BA1			3RV2021-4DA10
	2.2	3.0	6SE6420-2AB22-2BA1		3NA3812	3RV1031-4FA10
	3.0	4.0	6SE6420-2AB23-0CA1	6SE6400-0GP00-0CA0	3NA3817	3RV1031-4HA10
3 AC 200 V to 240 V	3.0	4.0	6SE6420-2AC23-0CA1	6SE6400-0GP00-0CA0	3NA3810	3RV2021-4CA10
	4.0	5.0	6SE6420-2AC24-0CA1		3NA3812	3RV1031-4EA10
	5.5	7.5	6SE6420-2AC25-5CA1		3NA3814	3RV1031-4FA10
3 AC 380 V to 480 V	2.2	3.0	6SE6420-2AD22-2BA1	6SE6400-0GP00-0BA0	3NA3805	3RV2011-1JA10
	3.0	4.0	6SE6420-2AD23-0BA1			3RV2011-1KA10
	4.0	5.0	6SE6420-2AD24-0BA1		3NA3807	3RV2021-4AA10
	5.5	7.5	6SE6420-2AD25-5CA1	6SE6400-0GP00-0CA0	3NA3810	3RV2021-4CA10
	7.5	10.0	6SE6420-2AD27-5CA1			3RV1031-4EA10
	11	15.0	6SE6420-2AD31-1CA1		3NA3814	3RV1031-4GA10

Overview**Basic Operator Panel (BOP)**

With the BOP, individual parameter settings can be made. Values and units are shown on a 5-digit display.



Basic Operator Panel (BOP)

A BOP can be used for several inverters. It can be directly mounted on the inverter or in a control cabinet door using a mounting kit.

Advanced Operator Panel (AOP)

The AOP enables parameter kits to be read out of the inverter or to be written into the inverter (upload/download). Different parameter kits can be stored in the AOP. It has a plain text display with the possibility of switching between several languages.



Advanced Operator Panel (AOP)

Up to 30 inverters can be controlled from an AOP via USS. It can be directly mounted on the inverter or in a control cabinet door using a mounting kit.

Asian Advanced Operator Panel (AAOP)

The AAOP is the Chinese version of the AOP operator panel. It has an enhanced display and supports the operating languages of Chinese (simplified) and English.



Asian Advanced Operator Panel (AAOP)

Cyrillic Advanced Operator Panel (CAOP)

The CAOP is the Cyrillic version of the AOP Advanced Operator Panel. It supports the Cyrillic, German and English operator languages.

PROFIBUS module

For a complete PROFIBUS connection with up to ≤ 12 Mbaud. Remote control of the inverter is possible with the PROFIBUS module. Remote control and operation at the inverter can be combined using an operator panel plugged onto the PROFIBUS module. The PROFIBUS module can be supplied by an external 24 V DC power supply and is thus also active when the inverter is disconnected from the power supply.

Connection by means of a 9-pin Sub-D connector (available as an option).

DeviceNet module

For networking the inverters to the DeviceNet fieldbus system widely used on the American market. A maximum transmission rate of 500 Kbaud is possible. Remote control of the inverter is possible with the DeviceNet module. Remote control and operation at the inverter can be combined using an operator panel plugged onto the DeviceNet module.

The connection to the DeviceNet bus system is made using a 5-pin connector with terminal strip.

CANopen module

Using the CANopen communications module, an inverter can be linked to the CANopen fieldbus system and remote control is then possible.

Remote control and operation at the inverter can be combined using an operator panel plugged onto the CANopen module.

The module is connected to the bus system through a 9-pin Sub-D connector.

Connection kit for PC to inverter

For controlling an inverter directly from a PC if the appropriate software has been installed (e.g. STARTER). Isolated RS-232 adapter module for reliable point-to-point connection to a PC. Includes a Sub-D connector and an RS-232 standard cable (3 m).

Connection kit for PC to AOP

For connecting a PC to an AOP or AAOP. Offline programming of inverters and archiving of parameter kits possible. Includes a desktop attachment kit for an AOP or AAOP, an RS-232 standard cable (3 m) with Sub-D connectors and a universal power supply unit.

Operator panel door mounting kit for single inverter

For mounting an operator panel in a control cabinet door. Degree of protection IP56. Contains a cable adapter module with screwless terminals for use with user's own RS-232-cables¹⁾.

AOP door mounting kit for multiple inverters (USS)

For mounting an AOP or AAOP in a control cabinet door. Degree of protection IP56. The AOP or AAOP can communicate with several inverters by means of the RS-485 USS protocol. The 4-pin connecting cable from the AOP or AAOP to the RS-485 terminals of the inverter and to the 24 V user terminal strip is not included²⁾.

Start-up tools

- **STARTER** is a graphic start-up software for guided start-up for MICROMASTER 410/420/430/440 frequency inverters under Windows 2000/XP Professional. Parameter lists can be read out, altered, stored, entered and printed.
- **DriveMonitor** is a start-up software for list-oriented programming of frequency inverters. This program executes under Windows 98/NT/2000/ME/XP Professional.

Both programs are included on the Docu DVD which is provided with every inverter.

1) A shielded cable of type Belden 8132 (28 AWG) is recommended. The maximum cable length is 5 m for RS-232.

2) A shielded cable of type Belden 8132 (28 AWG) is recommended. The maximum cable length is 10 m for RS-485.

MICROMASTER 420

Options

Variant independent options



Selection and ordering data

The options listed here are suitable for all MICROMASTER 420 inverters.

Options	Order No.
Basic Operator Panel (BOP)	6SE6400-0BP00-0AA0
Advanced Operator Panel (AOP)	6SE6400-0AP00-0AA1
Asian Advanced Operator Panel (AAOP)	6SE6400-0AP00-0AB0
Cyrillic Advanced Operator Panel (CAOP)	6SE6400-0AP00-0CA0
PROFIBUS module	6SE6400-1PB00-0AA0
DeviceNet module	6SE6400-1DN00-0AA0
CANopen module	6SE6400-1CB00-0AA0
RS485/PROFIBUS bus connector	6GK1500-0FC00
Connection kit for PC to inverter	6SE6400-1PC00-0AA0
Connection kit for PC to AOP	6SE6400-0PA00-0AA0
Operator panel door mounting kit for single inverter	6SE6400-0PM00-0AA0
AOP door mounting kit for multiple inverters (USS)	6SE6400-0MD00-0AA0
Start-up tool STARTER on DVD	6SL3072-0AA00-0AG0

Available on the Internet at:
<http://support.automation.siemens.com/WW/view/en/10804985/133100>

Technical data of the communication modules

PROFIBUS module 6SE6400-1PB00-0AA0		DeviceNet module 6SE6400-1DN00-0AA0
		
Size (height x width x depth)		161 mm x 73 mm x 46 mm
Degree of protection		IP20
Degree of pollution		2 to IEC 60664-1 (DIN VDE 0110/T1), no condensation permitted during operation
Strain resistance		to DIN IEC 60068-2-6 (if module is installed correctly)
• Stationary	Deflection	0.15 mm in the frequency range of 10 Hz to 58 Hz
	Acceleration	19.6 m/s ² in the frequency range of 58 Hz to 500 Hz
• Transport	Deflection	3.5 mm in the frequency range of 5 Hz to 9 Hz
	Acceleration	9.8 m/s ² in the frequency range of 9 Hz to 500 Hz
Climatic category (during operation)		3K3 to DIN IEC 60721-3-3
Cooling method		Natural air cooling
Permissible ambient or cooling agent temperature		
• Operation		–10 °C to +50 °C (+14 °F to +122 °F)
• Storage and transport		–25 °C to +70 °C (–13 °F to +158 °F)
Relative humidity (permissible humidity rating)		
• Operation		≤ 85 % (non-condensing)
• Storage and transport		≤ 95 %
Electromagnetic compatibility		
	Emission	to EN 55011 (1991) Class A
	Interference	to IEC 60801-3 and EN 61000-4-3
Power supply		
		6.5 V ± 5 %, max. 300 mA, internal from inverter or 24 V ± 10 %, max. 350 mA, external
Output voltage		6.5 V ± 5 %, max. 300 mA internal from inverter or 24 V, max. 60 mA from DeviceNet-Bus
		–
Data transmission rate		
		max. 12 Mbaud
		125, 250 and 500 Kbaud

Technical data of the communication modules (continued)

CANopen module
6SE6400-1CB00-0AA0

Size (height x width x depth)	161 mm x 73 mm x 46 mm
Degree of protection	IP20
Degree of pollution	2 to IEC 60664-1 (DIN VDE 0110/T1), no condensation permitted during operation
Strain resistance	to IEC 60068-2-6 (if module is installed correctly)
• Stationary	Deflection Acceleration 0.15 mm in the frequency range of 10 Hz to 58 Hz 19.6 m/s ² in the frequency range of 58 Hz to 500 Hz
• Transport	Deflection Acceleration 3.5 mm in the frequency range of 5 Hz to 9 Hz 9.8 m/s ² in the frequency range of 9 Hz to 500 Hz
Climatic category (during operation)	3K3 to DIN IEC 60721-3-3
Cooling method	Natural air cooling
Permissible ambient or cooling agent temperature	
• Operation	–10 °C to +50 °C (+14 °F to +122 °F)
• Storage	–40 °C to +70 °C (–40 °F to +158 °F)
• Transport	–25 °C to +70 °C (–13 °F to +158 °F)
Relative humidity (permissible humidity rating)	
• Operation	≤ 85 % (non-condensing)
• Storage and transport	≤ 95 %
Power supply	The CAN bus is supplied from the inverter power supply
Data transmission rate	10, 20, 50, 125, 250, 500, 800 Kbaud and 1 Mbaud

Documentation

Selection and ordering data

Type of documentation	Language	Order No.
Docu pack , supplied with each inverter, containing DVD ¹⁾ and Getting Started Guide ²⁾ (paper version)	Multilanguage	6SE6400-5AD00-1AP1
Operating instructions (paper version)	German, English, French, Italian, Spanish Available as pdf file on the Internet at http://support.automation.siemens.com/WW/view/en/10804926/133300	
Parameter list (paper version)	German, English, French, Italian, Spanish Available as pdf file on the Internet at http://support.automation.siemens.com/WW/view/en/10804926/133300	

1) The DVD contains operating instructions, parameter list, commissioning tools STARTER and DriveMonitor, multilanguage.

Available on the Internet:
DriveMonitor at
<http://support.automation.siemens.com/WW/view/en/10804984/133100>

STARTER at
<http://support.automation.siemens.com/WW/view/en/10804985/133100>

2) Available on the Internet at
<http://support.automation.siemens.com/WW/view/en/10804926/133300>

MICROMASTER 420

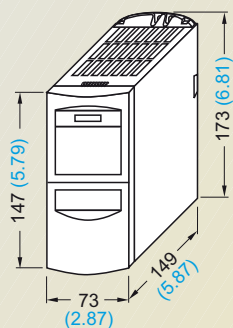
Dimension drawings

MICROMASTER 420 inverter

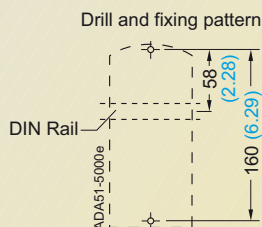
Frame size	1/3 AC 200 V to 240 V	3 AC 380 V to 480 V
A	0.12 kW to 0.75 kW	0.37 kW to 1.5 kW
B	1.1 kW to 2.2 kW	2.2 kW to 4 kW
C	3 kW to 5.5 kW	5.5 kW to 11 kW

Note:

The inverters must not be mounted horizontally.
But the inverters can be mounted without lateral spacing.

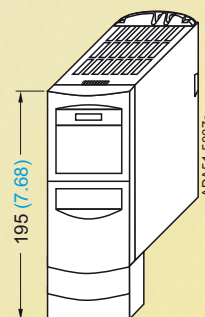


Inverter frame size **A**

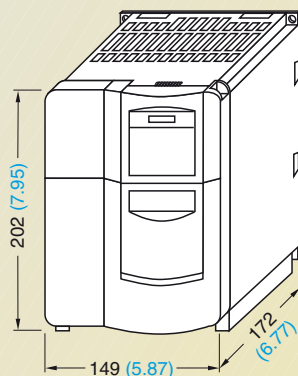


Fixing with
2 x M4 bolts, 2 x M4 nuts, 2 x M4 washers,
or snap onto the DIN rail
Tightening torque with washers fitted:
2.5 Nm

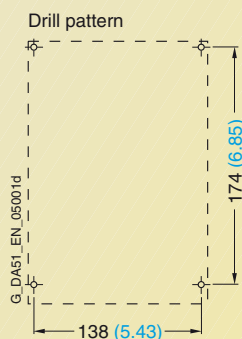
Ventilation clearance required at top and
bottom: 100 mm



Inverter frame size **A**
with **gland plate**

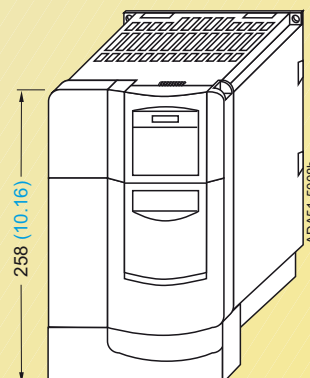


Inverter frame size **B**

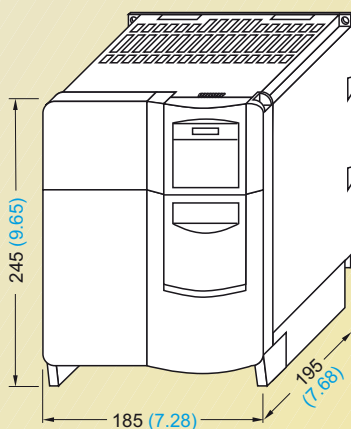


Fixing with
4 x M4 bolts, 4 x M4 nuts, 4 x M4 washers
Tightening torque with washers fitted:
2.5 Nm

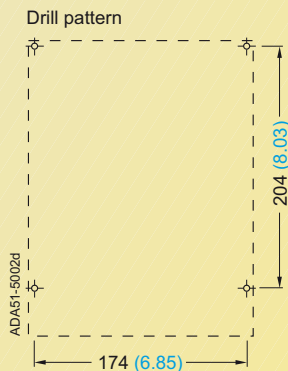
Ventilation clearance required at top and
bottom: 100 mm



Inverter frame size **B**
with **gland plate**

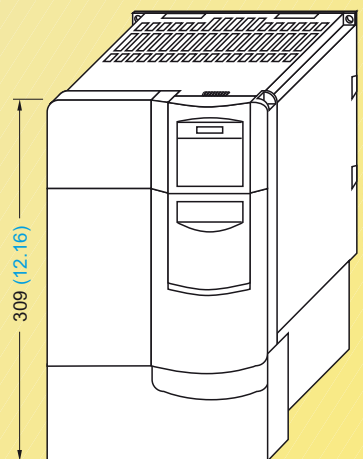


Inverter frame size **C**



Fixing with
4 x M5 bolts, 4 x M5 nuts, 4 x M5 washers
Tightening torque with washers fitted:
3.0 Nm

Ventilation clearance required at top
and bottom: 100 mm

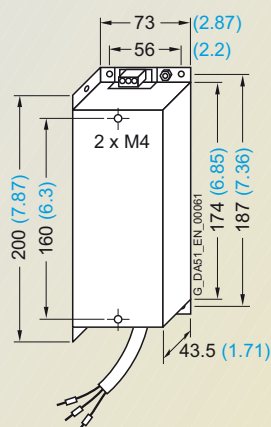
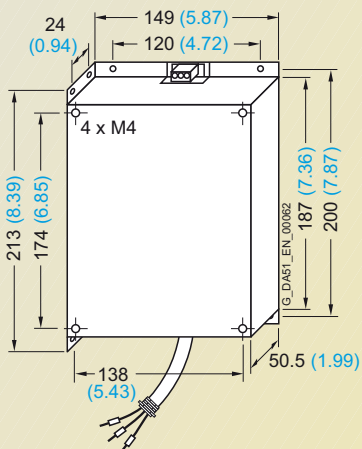
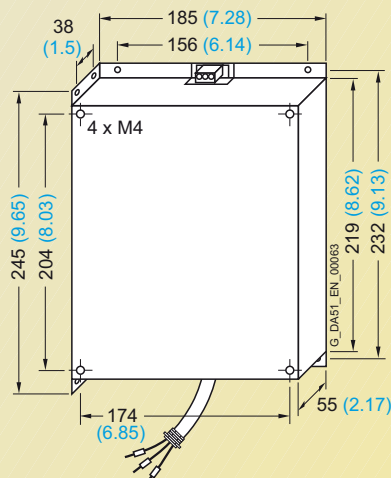
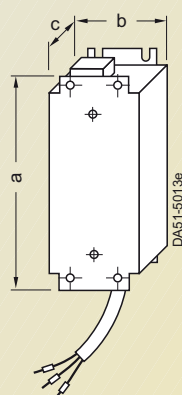
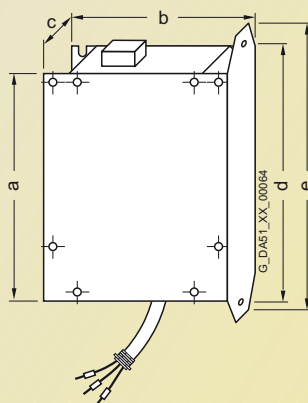


Inverter frame size **C**
with **gland plate**

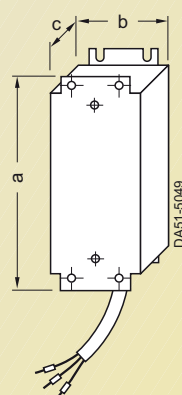
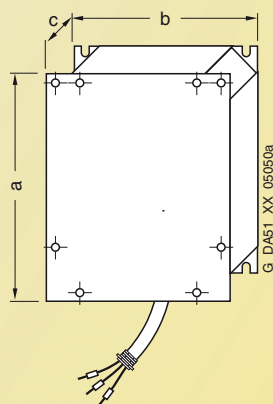
With the communications module, the mounting depth
increases by 23 mm (0.91 inches).

All dimensions in mm (values in brackets are in inches)

Filters and chokes

Filter frame size **A**For frame size **B**For frame size **C**Line commutating choke
for frame size **A**For frame sizes **B** and **C**

Line commutating choke for	Dimensions					Weight (max.) kg
	a	b	c	d	e	
Frame size A	200 (7.87)	75.5 (2.97)	50 (1.97)	–	–	1.4
Frame size B	213 (8.39)	150 (5.91)	50 (1.97)	220 (8.66)	233 (9.17)	2.2
Frame size C	245 (9.65)	185 (7.28)	50 (1.97)	264 (10.39)	280 (11.02)	5.1

Output choke
for frame size **A**
6SE6400-3TC00-4AD2
6SE6400-3TC00-4AD3For frame sizes **B** and **C**
6SE6400-3TC01-0BD3
6SE6400-3TC03-2CD3

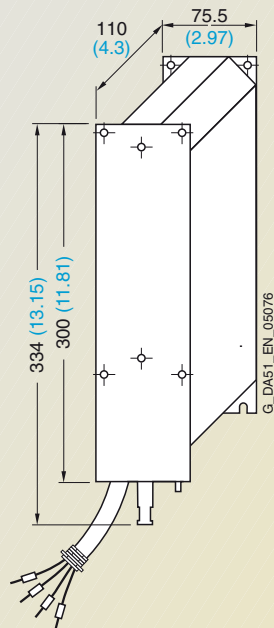
Output choke type 6SE6400-	Dimensions			Weight (max.) kg
	a	b	c	
3TC00-4AD2	200 (7.87)	75.5 (2.97)	110 (4.33)	1.9
3TC00-4AD3	200 (7.87)	75.5 (2.97)	50 (1.97)	1.3
3TC01-0BD3	213 (8.39)	150 (5.91)	80 (3.15)	4.1
3TC03-2CD3	245 (9.65)	185 (7.28)	80 (3.15)	6.6

All dimensions in mm (values in brackets are in inches)

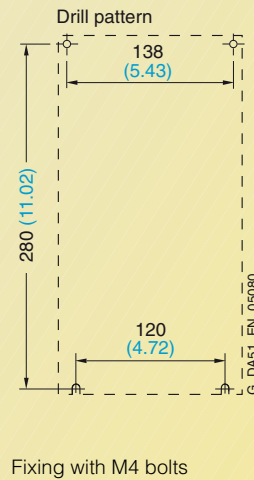
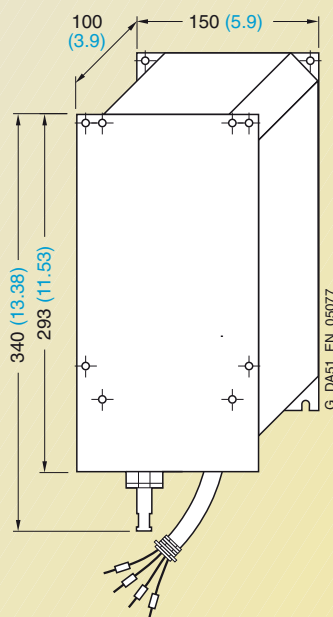
MICROMASTER 420

Dimension drawings

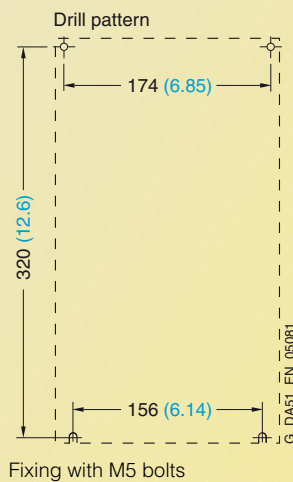
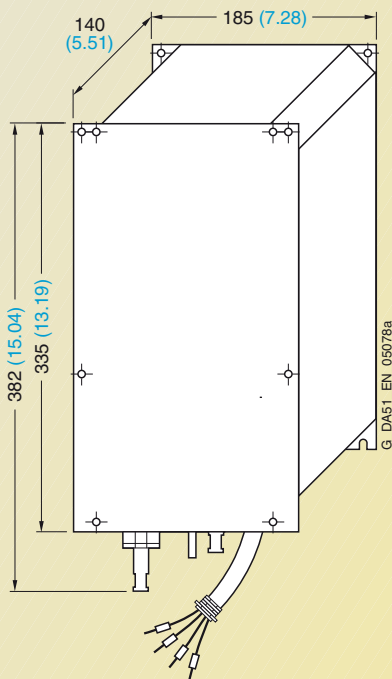
LC filter



LC filter for frame size A



LC filter for frame size B



LC filter for frame size C

All dimensions in mm (values in brackets are in inches)

Inverter

MICROMASTER 430



3/2	Description
3/4	Circuit diagrams
3/6	Technical data
3/9	Selection and ordering data
3/10	Options
3/19	Dimension drawings

MICROMASTER 430

Description



Application

The MICROMASTER 430 inverter is suitable for a variety of variable-speed drive applications. Its flexibility provides for a wide spectrum of applications. It is especially suitable for use with industrial pumps and fans. The inverter is especially characterized by its customer-oriented performance and ease-of-use. It has more inputs and outputs than the MICROMASTER 420, an optimized operator panel with manual/automatic switchover and adapted software functionality.

Design

The MICROMASTER 430 inverter has a modular design.

The operator panels and communication modules can be easily exchanged.

Main characteristics

- Easy, guided start-up
- Modular construction allows maximum configuration flexibility
- Six programmable isolated digital inputs
- Two scaleable analog inputs (0 V to 10 V, 0 mA to 20 mA) can also be used as a 7th/8th digital input
- Two programmable analog outputs (0 mA to 20 mA)
- Three programmable relay outputs (30 V DC/5 A resistive load; 250 V AC/2A inductive load)
- Low-noise motor operation thanks to high pulse frequencies, adjustable (observe derating if necessary)
- Complete protection for motor and inverter
- Control of up to three additional drives on the basis of PID control (motor staging)
- Operation of drive directly on mains (with external bypass circuit)
- Low-energy mode
- Detects dry run of pumps (belt failure detection).

Options (overview)

- Line commutating chokes
- Output chokes
- LC filter and sinusoidal filter
- Gland plates
- Basic Operator Panel 2 (BOP-2) for parameterizing the inverter
- Communication modules
 - PROFIBUS
 - DeviceNet
 - CANopen
- PC connection kits
- Mounting kits for installing the operator panels in the control cabinet doors
- PC start-up tools executable under Windows 98 and NT/2000/ME/XP Professional.
- TIA integration with Drive ES

International standards

- The MICROMASTER 430 inverter complies with the requirements of the EU low-voltage guideline
- The MICROMASTER 430 inverter has the **CE** marking
- acc. to **UL** and **cUL** certified
- c-tick **C**

Note:

See Appendix for standards.

Mechanical features

- Modular design
- Operating temperature
–10 °C to +40 °C
(+14 °F to +104 °F)
- Compact housing as a result of high power density
- Easy cable connection, mains and motor connections are separated for optimum electromagnetic compatibility
- Detachable operator panels
- Screwless control terminal strip on detachable I/O board.

Performance features

- Latest IGBT technology
- Digital microprocessor control
- Flux Current Control (FCC) for improved dynamic response and optimized motor control
- Linear V/f characteristic
- Quadratic V/f characteristic
- Multipoint characteristic (programmable V/f characteristic)
- Flying restart
- Slip compensation
- Automatic restart following mains failure or fault
- Energy saving mode (stopping e.g. of a pump at low speeds)
- Motor staging (connection and disconnection of additional motors, use of inverter as control drive in a pump cascade)
- Manual/automatic mode
- Load torque monitoring (belt failure detection; detects dry run of pumps)
- High-grade internal PID controller for simple process control
- Programmable acceleration/deceleration times from 0 s to 650 s
- Ramp smoothing
- Fast Current Limit (FCL) for trip-free operation
- Fast, repeatable digital input response time
- Fine adjustment using two high-resolution 10-bit analog inputs
- Compound braking for controlled rapid braking
- Four skip frequencies
- Removable “Y” capacitor for use on IT systems (with non-grounded mains supplies, the “Y” capacitor must be removed and an output choke installed).

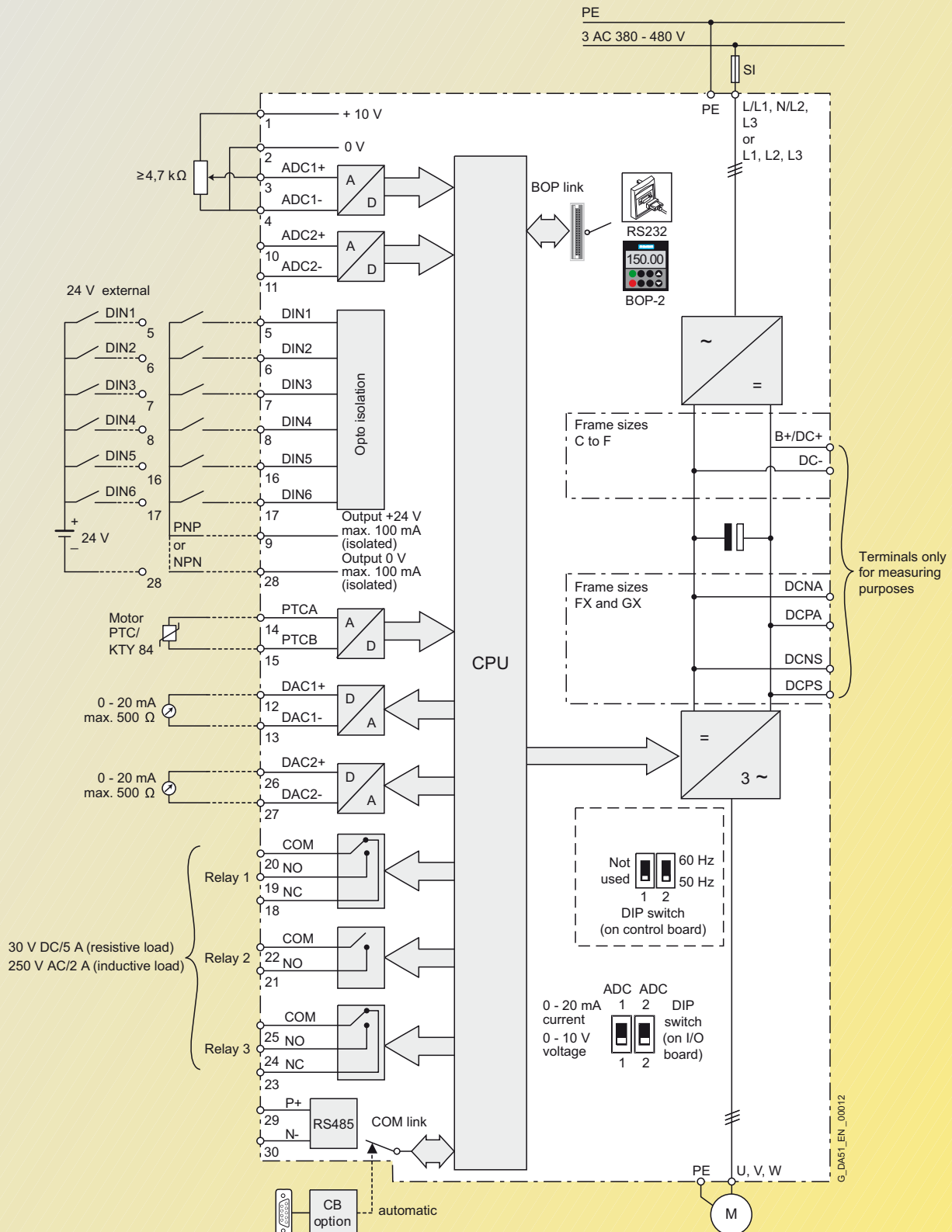
Protection features

- Overload capability
7.5 kW to 90 kW:
Overload current 1.4 x rated output current (i.e. +140 % overload capability) for 3 s, and 1.1 x rated output current (i.e. 110 % overload capability) for 60 s, cycle time 300 s
- 110 kW to 250 kW:
Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 1 s, and 1.1 x rated output current (i.e. 110 % overload capability) for 59 s, cycle time 300 s
- Overvoltage/undervoltage protection
- Inverter overtemperature protection
- Special direct connection for PTC or KTY to protect the motor
- Earth fault protection
- Short-circuit protection
- βt motor thermal protection
- Locked motor protection
- Stall prevention
- Parameter interlock

MICROMASTER 430

Circuit diagrams

General circuit diagram

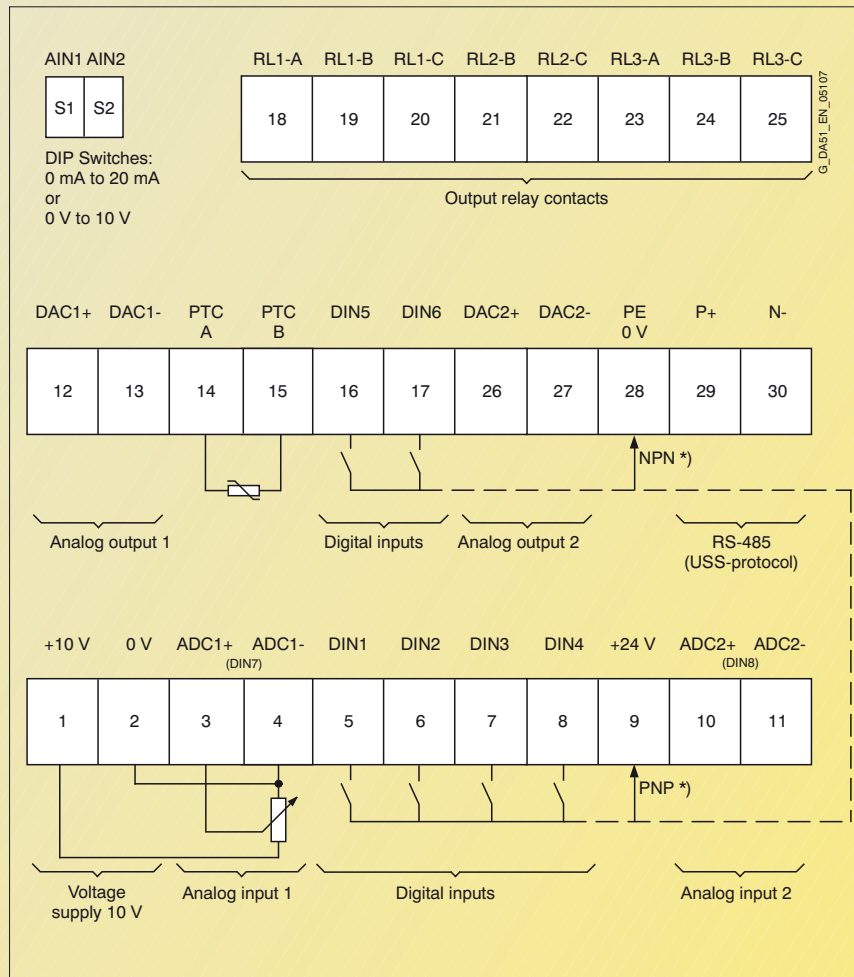


Terminal connection diagram

Example, frame size C



View A



*) PNP or NPN possible

MICROMASTER 430

Technical data

MICROMASTER 430 inverter

Mains voltage and Power ranges	3 AC 380 V to 480 V \pm 10 %	7.5 kW to 250 kW (variable torque)
Power frequency	47 Hz to 63 Hz	
Output frequency	7.5 kW to 90 kW 110 kW to 250 kW	0 Hz to 650 Hz (Due to legal restrictions a limitation to 550 Hz is under preparation) 0 Hz to 267 Hz
Power factor	\geq 0.95	
Inverter efficiency	7.5 kW to 90 kW 110 kW to 250 kW	96 % to 97 % 97 % to 98 % (Further information is available on the Internet at: http://support.automation.siemens.com/WW/view/en/22978972)
Overload capability	7.5 kW to 90 kW 110 kW to 250 kW	Overload current 1.4 x rated output current (i.e. +140 % overload capability) for 3 s, and 1.1 x rated output current (i.e. 110 % overload capability) for 60 s, cycle time 300 s Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 1 s and 1.1 x rated output current (i.e. 110 % overload capability) for 60 s, cycle time 300 s
Inrush current	Less than rated input current	
Control method	Linear V/f characteristic; quadratic V/f characteristic; multipoint characteristic (programmable V/f characteristic); flux current control (FCC), energy saving mode	
Pulse frequency	7.5 kW to 90 kW 110 kW to 250 kW	4 kHz (standard) 2 kHz to 16 kHz (in 2 kHz steps) 2 kHz (standard) 2 kHz to 4 kHz (in 2 kHz steps)
Fixed frequencies	15, programmable	
Skip frequency ranges	4, programmable	
Setpoint resolution	0.01 Hz digital; 0.01 Hz serial; 10 bit analog	
Digital inputs	6 fully programmable isolated digital inputs; switchable PNP/NPN	
Analog inputs	2 programmable analog inputs • 0 V to 10 V, 0 mA to 20 mA and -10 V to +10 V (AIN1) • 0 V to 10 V and 0 mA to 20 mA (AIN2) • both can be used as 7th/8th digital input	
Relay outputs	3, programmable, 30 V DC/5 A (resistive load); 250 V AC/2A (inductive load)	
Analog outputs	2, programmable (0/4 mA to 20 mA)	
Serial interfaces	RS-485, optional RS-232	
Motor cable length	7.5 kW to 90 kW without output choke with output choke 110 kW to 250 kW without output choke with output choke	max. 50 m (shielded); max. 100 m (unshielded) see variant dependent options max. 200 m (shielded); max. 300 m (unshielded) see variant dependent options
Electromagnetic compatibility	7.5 kW to 90 kW For inverters without filter 7.5 kW to 15 kW 18.5 kW to 90 kW 110 kW to 250 kW	Inverter with internal filter Class A available EMC filter, Class B to EN 55 011 available as an option EMC filter, Class B from Schaffner available as an option EMC filter, Class A available as an option
Braking	DC braking, compound braking	
Degree of protection	IP20	
Operating temperature range	7.5 kW to 90 kW 110 kW to 250 kW	-10 °C to +40 °C (+14 °F to +104 °F) 0 °C to +40 °C (+32 °F to +104 °F)
Storage temperature	-40 °C to +70 °C (-40 °F to +158 °F)	
Relative humidity	95 % (non-condensing)	
Installation altitude	7.5 kW to 90 kW 110 kW to 250 kW	Up to 1000 m above sea level without derating Up to 2000 m above sea level without derating
Standard SCCR (Short Circuit Current Rating) ¹⁾	FSC: 10 kA FSD, FSE, FSF, FSFX, FSGX: 65 kA	
Protection features for	undervoltage, overvoltage, overload, earth faults, short-circuits, stall prevention, locked motor protection, motor overtemperature, inverter overtemperature, parameter change protection	
Conformity with standards	7.5 kW to 90 kW 110 kW to 250 kW	CE, cUL, CE, c-tick UL available soon, cUL available soon, CE
CE marking	Conformity with low-voltage directive 73/23/EEC	
Cooling-air volumetric flow required, dimensions and weights (without options)	Frame size (FS)	Cooling-air volumetric flow required (l/s)/(CFM)
	C	54.9/116.3
	D	2 x 54.9/2 x 116.3
	E	2 x 54.9/2 x 116.3
	F without filter	150/317.79
	F with filter	150/317.79
	FX	225/478.13
	GX	440/935
	H	245 x 185 x 195
	x W	520 x 275 x 245
	x D (mm)	650 x 275 x 245
		850 x 350 x 320
		1150 x 350 x 320
		1400 x 326 x 356
		1533 x 326 x 545
		Weight, approx. (kg)
		5.7
		17
		22
		56
		75
		116
		174

1) For footnote, see page 3/7.

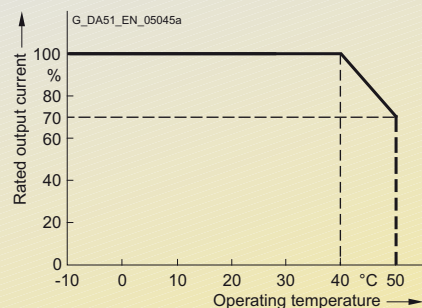
CFM: Cubic Feet per Minute

Derating data**Pulse frequency**

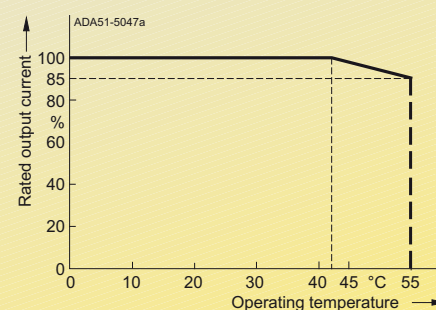
Output (for 3 AC 400 V) kW	Rated output current in A for a pulse frequency of							
	2 kHz	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz	14 kHz	16 kHz
7.5	19.0	19.0	17.1	15.2	13.3	11.4	9.5	7.6
11.0	26.0	26.0	24.7	23.4	20.8	18.2	15.6	13.0
15.0	32.0	32.0	28.8	25.6	22.4	19.2	16.0	12.8
18.5	38.0	38.0	36.1	34.2	30.4	26.6	22.8	19.0
22	45.0	45.0	40.5	36.0	31.5	27.0	22.5	18.0
30	62.0	62.0	55.8	49.6	43.4	37.2	31.0	24.8
37	75.0	75.0	71.3	67.5	60.0	52.5	45.0	37.5
45	90.0	90.0	81.0	72.0	63.0	54.0	45.0	36.0
55	110.0	110.0	93.5	77.0	63.3	49.5	41.3	33.0
75	145.0	145.0	123.3	101.5	83.4	65.3	54.4	43.5
90	178.0	178.0	138.0	97.9	84.6	71.2	62.3	53.4
110	205.0	180.4	—	—	—	—	—	—
132	250.0	220.0	—	—	—	—	—	—
160	302.0	265.8	—	—	—	—	—	—
200	370.0	325.6	—	—	—	—	—	—
250	477.0	419.8	—	—	—	—	—	—

Operating temperature

Inverter 7.5 kW to 90 kW



Inverter 110 kW to 250 kW



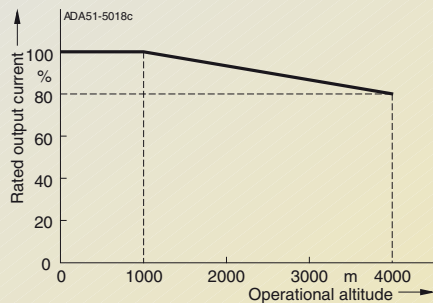
1) Applies to industrial control cabinet installations to NEC article 409/UL 508A.

Technical data

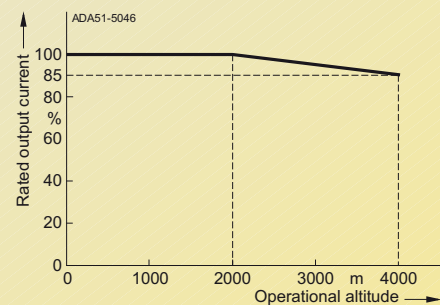
Derating data (continued)

Installation altitude above sea level

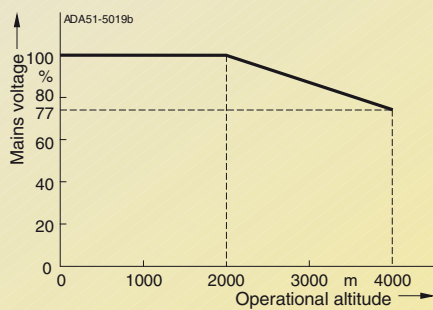
Permissible output current
in % of the rated output current
Inverter 7.5 kW to 90 kW



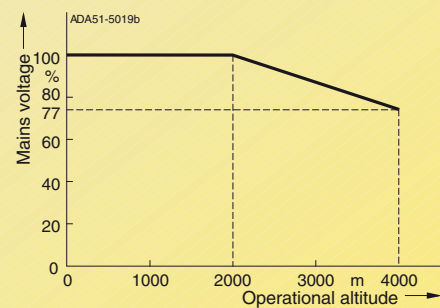
Inverter 110 kW to 250 kW



Permissible mains voltage
in % of the max. possible mains voltage
Inverter 7.5 kW to 90 kW



Inverter 110 kW to 250 kW



MICROMASTER 430 inverter

Output		Rated input current	Rated output current	Frame size	Order No.	
kW	hp	A	A	(FS)	MICROMASTER 430 without filter ⁴⁾	MICROMASTER 430 with internal filter Class A ³⁾
Mains operating voltage 3 AC 380 V to 480 V						
7.5	10	17.3 ¹⁾	19	C	6SE6430-2UD27-5CA0	6SE6430-2AD27-5CA0
11.0	15	23.1 ¹⁾	26	C	6SE6430-2UD31-1CA0	6SE6430-2AD31-1CA0
15.0	20	33.8 ¹⁾	32	C	6SE6430-2UD31-5CA0	6SE6430-2AD31-5CA0
18.5	25	37.0 ¹⁾	38	D	6SE6430-2UD31-8DA0	6SE6430-2AD31-8DA0
22	30	43.0 ¹⁾	45	D	6SE6430-2UD32-2DA0	6SE6430-2AD32-2DA0
30	40	59.0 ¹⁾	62	D	6SE6430-2UD33-0DA0	6SE6430-2AD33-0DA0
37	50	72.0 ¹⁾	75	E	6SE6430-2UD33-7EA0	6SE6430-2AD33-7EA0
45	60	87.0 ¹⁾	90	E	6SE6430-2UD34-5EA0	6SE6430-2AD34-5EA0
55	75	104.0 ¹⁾	110	F	6SE6430-2UD35-5FA0	6SE6430-2AD35-5FA0
75	100	139.0 ¹⁾	145	F	6SE6430-2UD37-5FA0	6SE6430-2AD37-5FA0
90	120	169.0 ¹⁾	178	F	6SE6430-2UD38-8FA0	6SE6430-2AD38-8FA0
110	150	200.0 ²⁾	205	FX	6SE6430-2UD41-1FA0	–
132	200	245.0 ²⁾	250	FX	6SE6430-2UD41-3FA0	–
160	250	297.0 ²⁾	302	GX	6SE6430-2UD41-6GA0	–
200	300	354.0 ²⁾	370	GX	6SE6430-2UD42-0GA0	–
250	350	442.0 ²⁾	477	GX	6SE6430-2UD42-5GA0	–



See Appendix for note on ordering.

All MICROMASTER 430 inverters are supplied with a Status Display Panel (SDP). A BOP-2 or other options have to be ordered separately (see Pages 3/14 to 3/16).

Motors for MICROMASTER 430

Catalog D 81.1 contains selection and ordering data for motors which are particularly suitable for operation with the MICROMASTER 430 inverters (see Appendix for overview).

This catalog is suitable for IEC motors. For motors according to US standards (NEMA) please refer to Catalog D 81.2 U.S./Canada (see Appendix for overview) and to: <http://www.sea.siemens.com/motors>

1) Supplementary conditions: Input current at rated operating point, applicable at short-circuit voltage of the supply $U_{sc} = 2\%$ with reference to the inverter rated power and rated mains operating voltage of 400 V without a line commutating choke.

2) Supplementary conditions: Input current at rated operating point, applicable at short-circuit voltage of the supply $U_{sc} \geq 2.33\%$ with reference to the inverter rated power and rated mains voltage of 400 V.

3) Use of MICROMASTER inverters with internal filter is not permissible on non-grounded mains supplies.

4) Acc. to EMC EN 61800-3 generally suited to heavy industrial applications. For details please refer to Appendix on page A/4.

MICROMASTER 430

Options

Variant dependent options

Overview

EMC filter, Class A

All 7.5 kW to 90 kW inverters are supplied with an internal filter Class A.

For inverters 110 kW to 250 kW, EMC filters Class A are available. In this performance range, the EMC filters are only permitted to be used in combination with a line commutating choke.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

EMC filter, Class B

Available for inverters 7.5 kW to 15 kW with an internal Class A EMC filter.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

For inverters 18.5 kW to 90 kW without filters, EMC filters of Class B from Schaffner can be used.

The requirements are fulfilled using shielded cables with a max. length of 25 m to 50 m (depending on the type, details on request).

With this filter, the inverter complies with the emission standard EN 55 011, Class B for conducted interference emissions.

Leakage currents:

The leakage currents of the inverters with/without filter (internal/external) may exceed 30 mA. Typical values in practice are between 10 mA and 50 mA. The exact values depend on the design, environment and cable lengths. Interference-free operation with residual current operated devices with a trigger value of 30 mA cannot be guaranteed.

However, operation with residual current operated devices with a trigger value of 300 mA is possible. Please refer to the Instruction Manual for details.

LC filter and sinusoidal filter

The LC filter/sinusoidal filter limits the rate of rise of voltage and the capacitive charge/discharge currents which usually occur with inverter operation. This means that much longer shielded motor cables are possible when using LC filters/sinusoidal filters and the service life of the motor achieves values similar to those with direct mains operation. Use of an output choke isn't required with that.

Please note when using LC filters/sinusoidal filters:

- Only V/f, FCC control permissible
- Please observe the derating of 15 % when selecting the appropriate inverter
- Operation only permissible with 4 kHz pulse frequency
Note: Please observe derating for frame sizes FX and GX.
- The output frequency is limited to 150 Hz
- Operation and commissioning only with connected motor as the LC filter/sinusoidal filter is not idling-proof!

The LC filters/sinusoidal filters can be used for all MICRO-MASTER 430 inverters of frame sizes C to GX.

- Frame sizes D to F:
The LC filters, frame sizes D to F, are designed for mounting upright in the control cabinet. Due to leakage flux lines caused by physical sources, a minimum distance of 50 mm to adjacent modules and metal parts is recommended.
- Frame sizes FX and GX:
The sinusoidal filters, frame sizes FX and GX, are designed for mounting upright in the control cabinet. Due to leakage flux lines caused by physical sources, a minimum distance of 100 mm to adjacent modules and metal parts is recommended.

Technical data

LC filter and sinusoidal filter

Mains voltage	3 AC 380 V to 480 V
Current (at 40 °C/50 °C)	
For frame size C (7.5 to 15 kW)	32.6 A/ 26 A
For frame size D (18.5 kW)	38.8 A/ 32 A
For frame size D (22 kW)	45.9 A/ 38 A
For frame size D (30 kW)	63.2 A/ 45 A
For frame size E (37 kW)	76.5 A/ 62 A
For frame size E (45 kW)	112.2 A/ 90 A
For frame size F (55 kW)	112.2 A/ 90 A
For frame size F (75 kW)	147.9 A/110 A
For frame size F (90 kW)	181.6 A/145 A
Current (at 40 °C/55 °C)	
For frame size FX (110 kW and 132 kW)	225 A/191 A
For frame size GX (160 kW)	276 A/235 A
For frame size GX (200 kW)	333 A/283 A
For frame size GX (250 kW)	408 A/347 A
Limiting of motor overvoltage	≤ 1078 V
dV/dt limiting	≤ 500 V/μs
Pulse frequency	4 kHz
Max. motor frequency	150 Hz

Technical data (continued)**LC filter and sinusoidal filter**

Max. permissible motor cable lengths			
For frame sizes C to F	shielded	200 m	
	unshielded	300 m	
For frame sizes FX and GX	shielded	300 m	
	unshielded	450 m	
Insulation strength		Overvoltage category III to VDE 0110	
Electromagnetic compatibility			
For frame sizes C to F		Up to 200 m motor cable length with emissions to Class A according to EN 55 011 in conjunction with filtered inverters and unshielded cables	
For frame sizes FX and GX		Up to 150 m motor cable length with emissions to Class A according to EN 55 011 in conjunction with filtered inverters and unshielded cables	
Conformity		CE according to the low-voltage directive 73/23/EEC	
Approvals		cUL E 219022	
Strain resistance		EN 60 068-2-31	
Humidity		95 % humidity, non-condensing	
Degree of protection			
For frame size C		IP20 (to EN 60 529)	
For frame sizes D to F		IP00/IP20 (to EN 60 529 with terminal covers)	
For frame sizes FX and GX		IP00	
Insulation class		H (180 °C)	
Temperature range			
For frame sizes C to F	Operation	–10 °C to +40 °C (+14 °F to +104 °F)	100 % P_n
		to +50 °C (to +122 °F)	80 % P_n
	Storage	–25 °C to +70 °C (–13 °F to +158 °F)	
For frame sizes FX and GX	Operation	–10 °C to +40 °C (+14 °F to +104 °F)	100 % P_n
		to +55 °C (to +131 °F)	85 % P_n
	Storage	–40 °C to +70 °C (–40 °F to +158 °F)	
Installation altitude			
For frame size C		Up to 2000 m:	100 % P_n
		2000 to 4000 m:	62.5 % P_n
For frame sizes D to F		Up to 1000 m:	100 % P_n
		1000 to 4000 m:	12.5 % derating for each 1000 m
For frame sizes FX and GX		Up to 2000 m:	100 % P_n
		2000 to 4000 m:	7.5 % derating for each 1000 m
Mounting position			
For frame size C		Footprint or suspended	
For frame sizes D to F, FX and GX		upright	
Free space			
For frame size C	Top	100 mm	
	Bottom	100 mm	
	Side	100 mm	
For frame sizes D to F, FX and GX	Top	100 mm	
	Side	100 mm	
Connection system	Input, litz wire or terminal	1U1, 1V1, 1W1	
	Output, terminals	1U2, 1V2, 1W2	
Torque for conductor connections		Terminal cross-section	Torque
For frame size C		–	1.5 Nm to 1.8 Nm
For frame sizes D to F		16 mm ²	2.0 Nm to 4.0 Nm
		35 mm ²	2.5 Nm to 5.0 Nm
		50 mm ²	3.0 Nm to 6.0 Nm
		95 mm ²	6.0 Nm to 12.0 Nm
		150 mm ²	10.0 Nm to 20.0 Nm
For frame sizes FX and GX		–	14.0 Nm to 31.0 Nm
Weight, approx.			
For frame size C		8.5 kg	to 29 kg
For frame size D		21 kg	to 34 kg
For frame size E		49.5 kg	to 67 kg
For frame size F		67 kg	to 77.5 kg
For frame size FX		135 kg	
For frame size GX		138 kg	to 208 kg

MICROMASTER 430

Options

Variant dependent options

Overview

Line commutating choke

Line commutating chokes are used to smooth voltage peaks or to bridge commutating dips.

In addition, line commutating chokes reduce the effects of harmonics on the inverter and the power supply. If the line impedance is $< 1\%$, a line commutating choke must be used in order to reduce the current peaks.

No limits are currently defined in the EN 61 000-3-2 standard for professionally used devices with a connected load > 1 kW.

This means that the inverters with an output power ≥ 0.75 kW comply with the EN 61 000-3-2 standard.

However, in accordance with the regulations of EN 61000-3-12 "Limits for harmonic currents > 16 A and ≤ 75 A per phase" an approval is necessary from the power supplier for drives that are intended to be connected to the public low-voltage network. Please refer to the Operating Instructions for the values of the harmonic currents.

Output choke

Output chokes can be supplied for reducing the capacitive compensation currents and dV/dt in the case of motor cables > 50 m (shielded) or > 100 m (unshielded).

For max. permissible cable lengths, see Technical Data.

Gland plate

Gland plates are available for inverters of frame size C. All the other frame sizes have the shield connection for the control cable integrated in the inverter.

The shield for the power cable has to be connected externally (e.g. in the control cabinet). Exception: Inverters of frame sizes D and E and frame size F with integrated class A filter. In this case the shield connection is integrated in the inverter.

The gland plate facilitates the shield connection of power and control cables and thus ensures optimum EMC performance.

Technical data

Max. permissible cable lengths from the motor to the inverter when using output chokes

The following table shows the maximum permissible cable lengths from the motor to the inverter when using output chokes.

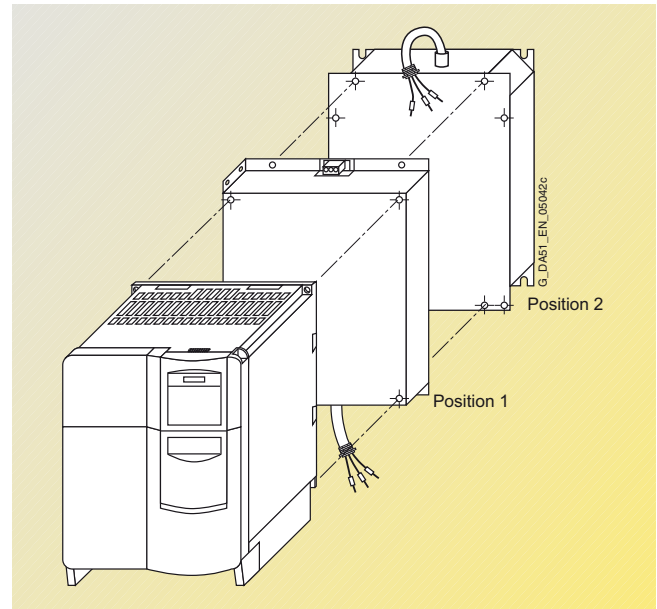
Note:

Operation up to 150 Hz output frequency only!

Frame size (FS)	Output choke Type	Max. permissible motor cable lengths (shielded/unshielded) for a mains voltage of	
		380 V to 400 V $\pm 10\%$	401 V to 480 V $\pm 10\%$
C	6SE6400-3TC03-2CD3	200 m/300 m	100 m/150 m
D to F	6SE6400-3TC...D0	200 m/300 m	200 m/300 m
FX	6SL3000-2BE32-1AA0	300 m/450 m	300 m/450 m
FX	6SL3000-2BE32-6AA0	300 m/450 m	300 m/450 m
GX	6SL3000-2BE33-2AA0	300 m/450 m	300 m/450 m
GX	6SL3000-2BE33-8AA0	300 m/450 m	300 m/450 m
GX	6SL3000-2BE35-0AA0	300 m/450 m	300 m/450 m

Design**General installation instructions**

- A maximum of two footprint components plus inverter are permissible.
- If an LC filter is used, it must be mounted directly on the wall of the control cabinet due to weight reasons. If an LC filter of frame size C is used, therefore, only one footprint component is permissible. If a line choke and LC filter are used, the line choke must be located on the left of the inverter. Required distance between line choke and inverter: 75 mm.
- The EMC filter must be mounted directly below the frequency inverter if possible.
- If mounted on the side, the line-side components are to be mounted to the left of the frequency inverter whereas the output-side components are to be mounted to the right of the frequency inverter.



Example of installation with frequency inverter, EMC filter (position 1) and line choke (position 2)

Availability of the options as footprint components

	Frame size						
	C	D	E	F	G	FX	GX
Line commutating choke	✓	✓	✓				
EMC filter	✓						
LC filter	✓						
Output choke	✓						

Recommended combinations of inverters and options

Frequency inverter Frame size	Footprint		Mounted on side	
	Position 1	Position 2	To the left of the inverter (for line-side components)	To the right of the inverter (for output-side components)
C	EMC filter	Line commutating choke	–	Output choke
	EMC filter <u>or</u> Line commutating choke	Output choke	–	–
	LC filter	–	EMC filter <u>and/or</u> Line commutating choke	–
D and E	Line commutating choke	–	EMC filter	Output choke <u>or</u> LC filter
F, G, FX and GX	–	–	EMC filter <u>and/or</u> Line commutating choke	Output choke <u>or</u> LC filter

MICROMASTER 430

Options

Variant dependent options

Selection and ordering data

The options listed here (filters, chokes, gland plates, fuses and circuit-breakers) must be selected to match the inverter.

The inverter and the associated options have the same voltage ratings. Alternatively fuses and circuit-breakers can be

provided. Both provide short circuit protection of the inverter supply line and the inverter. A semiconductor protection of

the inverter with the suggested 3NA... fuses and the 3RV.../3VL... circuit-breakers is not envisaged.




Mains voltage	Output kW	hp	Inverter without filter	Order No. of the options EMC filter, Class A	EMC filter, Class B	Line commutating choke
3 AC 380 V to 480 V	7.5	10	6SE6430-2UD27-5CA0	–	–	6SE6400-3CC02-2CD3
	11.0	15	6SE6430-2UD31-1CA0	–	–	
	15.0	20	6SE6430-2UD31-5CA0	–	–	6SE6400-3CC03-5CD3
	18.5	25	6SE6430-2UD31-8DA0	–	EMC filter, Class B, available from Schaffner	6SE6400-3CC04-4DD0
	22	30	6SE6430-2UD32-2DA0	–		
	30	40	6SE6430-2UD33-0DA0	–		6SE6400-3CC05-2DD0
	37	50	6SE6430-2UD33-7EA0	–		6SE6400-3CC08-3ED0
	45	60	6SE6430-2UD34-5EA0	–		
	55	75	6SE6430-2UD35-5FA0	–		6SE6400-3CC11-2FD0
	75	100	6SE6430-2UD37-5FA0	–		
	90	120	6SE6430-2UD38-8FA0	–		6SE6400-3CC11-7FD0
	110	150	6SE6430-2UD41-1FA0	6SL3000-0BE32-5AA0 *)	–	6SL3000-0CE32-3AA0
	132	200	6SE6430-2UD41-3FA0	6SL3000-0BE34-4AA0 *)	–	6SL3000-0CE32-8AA0
	160	250	6SE6430-2UD41-6GA0	–	–	6SL3000-0CE33-3AA0
	200	300	6SE6430-2UD42-0GA0	–	–	6SL3000-0CE35-1AA0
	250	350	6SE6430-2UD42-5GA0	6SL3000-0BE36-0AA0 *)	–	

*) Must be used in combination with a line commutating choke.

Mains voltage	Output kW	hp	Inverter without filter	Order No. of the options LC/sinusoidal filter	Output choke	Gland plate
3 AC 380 V to 480 V	7.5	10	6SE6430-2UD27-5CA0	6SE6400-3TD03-2CD0	6SE6400-3TC03-2CD3	6SE6400-0GP00-0CA0
	11.0	15	6SE6430-2UD31-1CA0			
	15.0	20	6SE6430-2UD31-5CA0			
	18.5	25	6SE6430-2UD31-8DA0	6SE6400-3TD03-7DD0	6SE6400-3TC05-4DD0	Integrated as standard for shield connection of the control cable and the power cable.
	22	30	6SE6430-2UD32-2DA0	6SE6400-3TD04-8DD0	6SE6400-3TC03-8DD0	
	30	40	6SE6430-2UD33-0DA0	6SE6400-3TD06-1DD0	6SE6400-3TC05-4DD0	
	37	50	6SE6430-2UD33-7EA0	6SE6400-3TD07-2ED0	6SE6400-3TC08-0ED0	
	45	60	6SE6430-2UD34-5EA0	6SE6400-3TD11-5FD0	6SE6400-3TC07-5ED0	
	55	75	6SE6430-2UD35-5FA0		6SE6400-3TC14-5FD0	Integrated as standard for shield connection of the control cable. The shield of the power cable has to be connected externally (e.g. in the control cabinet).
	75	100	6SE6430-2UD37-5FA0	6SE6400-3TD15-0FD0	6SE6400-3TC15-4FD0	
	90	120	6SE6430-2UD38-8FA0	6SE6400-3TD18-0FD0	6SE6400-3TC14-5FD0	
	110	150	6SE6430-2UD41-1FA0	6SL3000-2CE32-3AA0	6SL3000-2BE32-1AA0	
	132	200	6SE6430-2UD41-3FA0		6SL3000-2BE32-6AA0	
	160	250	6SE6430-2UD41-6GA0	6SL3000-2CE32-8AA0	6SL3000-2BE33-2AA0	
	200	300	6SE6430-2UD42-0GA0	6SL3000-2CE33-3AA0	6SL3000-2BE33-8AA0	
	250	350	6SE6430-2UD42-5GA0	6SL3000-2CE34-1AA0	6SL3000-2BE35-0AA0	


Mains voltage	Output kW	hp	Inverter without filter	Order No. of the options Fuses (see Catalog LV 10) 3NA3	3NE1 (see page 3/15)	Circuit-breaker (see Catalog IC 10/LV 10)
3 AC 380 V to 480 V	7.5	10	6SE6430-2UD27-5CA0	3NA3807	● (see page 3/15)	3RV1031-4EA10
	11.0	15	6SE6430-2UD31-1CA0	3NA3812		3RV1031-4FA10
	15.0	20	6SE6430-2UD31-5CA0	3NA3814		3RV1031-4HA10
	18.5	25	6SE6430-2UD31-8DA0	3NA3820		3RV1042-4KA10
	22	30	6SE6430-2UD32-2DA0	3NA3822	3NE1817-0	
	30	40	6SE6430-2UD33-0DA0	3NA3824	3NE1818-0	
	37	50	6SE6430-2UD33-7EA0	3NA3830	3NE1820-0	3RV1042-4MA10
	45	60	6SE6430-2UD34-5EA0	3NA3832	3NE1021-0	3VL1712-.DD33-....
	55	75	6SE6430-2UD35-5FA0	3NA3836	3NE1022-0	3VL1716-.DD33-....
	75	100	6SE6430-2UD37-5FA0	3NA3836	3NE1224-0	3VL3720-.DC36-....
	90	120	6SE6430-2UD38-8FA0	3NA3140	3NE1225-0	3VL3725-.DC36-....
	110	150	6SE6430-2UD38-8FA0	3NA3144	3NE1227-0	
	132	200	6SE6430-2UD41-1FA0	–		3VL4731-.DC36-....
	160	250	6SE6430-2UD41-3FA0	–	3NE1230-0	
	200	300	6SE6430-2UD41-6GA0	–	3NE1332-0	
	250	350	6SE6430-2UD42-0GA0	–	3NE1333-0	3VL4740-.DC36-....
			6SE6430-2UD42-5GA0	–	3NE1435-0	3VL5750-.DC36-....

Selection and ordering data (continued)

All options are certified to , except fuses.
The 3NE1 fuses are -listed (equivalent to ).


The fuses of type 3NA3 as well as circuit-breakers of type 3RV/3VL are recommended for Europe.

Additional information on the listed fuses and circuit-breakers can be found in Catalogs LV 10 and IC 10.

● Use in America requires -listed fuses Class J.

Mains voltage	Output		Inverter with internal filter Class A	Order No. of the options		
	kW	hp		Additional EMC filter, Class B	Line commutating choke	LC filter
3 AC 380 V to 480 V	7.5	10	6SE6430-2AD27-5CA0	6SE6400-2FS03-8CD0	6SE6400-3CC02-2CD3	6SE6400-3TD03-2CD0
	11.0	15	6SE6430-2AD31-1CA0			
	15.0	20	6SE6430-2AD31-5CA0		6SE6400-3CC03-5CD3	
	18.5	25	6SE6430-2AD31-8DA0	An inverter without filter must be selected to satisfy the EMC requirements of Class B. In addition, an appropriate EMC filter of Class B is from Schaffner is required.	6SE6400-3CC04-4DD0	6SE6400-3TD03-7DD0
	22	30	6SE6430-2AD32-2DA0			6SE6400-3TD04-8DD0
	30	40	6SE6430-2AD33-0DA0		6SE6400-3CC05-2DD0	6SE6400-3TD06-1DD0
	37	50	6SE6430-2AD33-7EA0		6SE6400-3CC08-3ED0	6SE6400-3TD07-2ED0
	45	60	6SE6430-2AD34-5EA0			6SE6400-3TD11-5FD0
	55	75	6SE6430-2AD35-5FA0		6SE6400-3CC11-2FD0	
	75	100	6SE6430-2AD37-5FA0			6SE6400-3TD15-0FD0
	90	120	6SE6430-2AD38-8FA0		6SE6400-3CC11-7FD0	6SE6400-3TD18-0FD0

Mains voltage	Output		Inverter with internal filter Class A	Order No. of the options	
	kW	hp		Output choke	Gland plate
3 AC 380 V to 480 V	7.5	10	6SE6430-2AD27-5CA0	6SE6400-3TC03-2CD3	6SE6400-0GP00-0CA0
	11.0	15	6SE6430-2AD31-1CA0		
	15.0	20	6SE6430-2AD31-5CA0		
	18.5	25	6SE6430-2AD31-8DA0	6SE6400-3TC05-4DD0	Integrated as standard for shield connection of the control cable and the power cable.
	22	30	6SE6430-2AD32-2DA0	6SE6400-3TC03-8DD0	
	30	40	6SE6430-2AD33-0DA0	6SE6400-3TC05-4DD0	
	37	50	6SE6430-2AD33-7EA0	6SE6400-3TC08-0ED0	
	45	60	6SE6430-2AD34-5EA0	6SE6400-3TC07-5ED0	
	55	75	6SE6430-2AD35-5FA0	6SE6400-3TC14-5FD0	
	75	100	6SE6430-2AD37-5FA0	6SE6400-3TC15-4FD0	
	90	120	6SE6430-2AD38-8FA0	6SE6400-3TC14-5FD0	

Mains voltage	Output		Inverter with internal filter Class A	Order No. of the options		Circuit-breaker (see Catalog IC 10/LV 10)
	kW	hp		Fuses (see Catalog LV 10) 3NA3	3NE1 ()	
3 AC 380 V to 480 V	7.5	10	6SE6430-2AD27-5CA0	3NA3807	●	3RV1031-4EA10
	11.0	15	6SE6430-2AD31-1CA0	3NA3812		3RV1031-4FA10
	15.0	20	6SE6430-2AD31-5CA0	3NA3814		3RV1031-4HA10
	18.5	25	6SE6430-2AD31-8DA0	3NA3820	3NE1817-0	3RV1042-4KA10
	22	30	6SE6430-2AD32-2DA0	3NA3822	3NE1818-0	
	30	40	6SE6430-2AD33-0DA0	3NA3824	3NE1820-0	3RV1042-4MA10
	37	50	6SE6430-2AD33-7EA0	3NA3830	3NE1021-0	3VL1712-.DD33-....
	45	60	6SE6430-2AD34-5EA0	3NA3832	3NE1022-0	3VL1716-.DD33-....
	55	75	6SE6430-2AD35-5FA0	3NA3836	3NE1224-0	3VL3720-.DC36-....
	75	100	6SE6430-2AD37-5FA0	3NA3140	3NE1225-0	3VL3725-.DC36-....
	90	120	6SE6430-2AD38-8FA0	3NA3144	3NE1227-0	

MICROMASTER 430

Options

Variant independent options

Overview

Basic Operator Panel 2 (BOP-2)

With the BOP-2, individual parameter settings can be made. Values and units are shown on a 5-digit display.



Basic Operator Panel (BOP-2)

A BOP-2 can be used for several inverters. It can be directly mounted on the inverter or in a control cabinet door using a mounting kit.

PROFIBUS module

For a complete PROFIBUS connection with up to ≤ 12 Mbaud. Remote control of the inverter is possible with the PROFIBUS module. Remote control and operation at the inverter can be combined using an operator panel plugged onto the PROFIBUS module. The PROFIBUS module can be supplied by an external 24 V DC power supply and is thus also active when the inverter is disconnected from the power supply.

Connection by means of a 9-pin Sub-D connector (available as an option).

DeviceNet module

For networking the inverters to the DeviceNet fieldbus system widely used on the American market. A maximum transmission rate of 500 kbaud is possible. Remote control of the inverter is possible with the DeviceNet module.

Remote control and operation at the inverter can be combined using an operator panel plugged onto the DeviceNet module.

The connection to the DeviceNet bus system is made using a 5-pin connector with terminal strip.

CANopen module

Using the CANopen communications module, an inverter can be linked to the CANopen fieldbus system and remote control is then possible.

Remote control and operation at the inverter can be combined using an operator panel plugged onto the CANopen module.

The module is connected to the bus system through a 9-pin Sub-D connector.

Connection kit for PC to inverter

For controlling an inverter directly from a PC if the appropriate software has been installed (e.g. STARTER). Isolated RS-232 adapter module for reliable point-to-point connection to a PC. Includes a Sub-D connector and an RS-232 standard cable (3 m).

Operator panel door mounting kit for single inverter

For mounting an operator panel BOP-2 in a control cabinet door. Degree of protection IP56. Contains a cable adapter module with screwless terminals for use with user's own RS-232 cables ¹⁾.

Start-up tools

- **STARTER** is a graphic start-up software for guided start-up for MICROMASTER 410/420/430/440 frequency inverters under Windows 2000/XP Professional. Parameter lists can be read out, altered, stored, entered and printed.
- **DriveMonitor** is a start-up software for list-oriented programming of frequency inverters. This program executes under Windows 98/NT/2000/ME/XP Professional.

Both programs are included on the Docu DVD which is provided with every inverter.

¹⁾ A shielded cable of type Belden 8132 (28 AWG) is recommended. The maximum cable length is 5 m for RS-232.

Selection and ordering data

The options listed here are suitable for all MICROMASTER 430 inverters.

Options	Order No.	
Basic Operator Panel 2 (BOP-2)	6SE6400-0BE00-0AA0	
PROFIBUS module	6SE6400-1PB00-0AA0	
DeviceNet module	6SE6400-1DN00-0AA0	
CANopen module	6SE6400-1CB00-0AA0	
RS485/PROFIBUS bus connector	6GK1500-0FC00	
Connection kit for PC to inverter	6SE6400-1PC00-0AA0	
Operator panel door mounting kit for single inverter	6SE6400-0PM00-0AA0	
Start-up tool STARTER on DVD	6SL3072-0AA00-0AG0	Available on the Internet at: http://support.automation.siemens.com/WW/view/en/10804985/133100

Technical data of the communication modules

PROFIBUS module
6SE6400-1PB00-0AA0**DeviceNet module**
6SE6400-1DN00-0AA0

Size (height x width x depth)		161 mm x 73 mm x 46 mm
Degree of protection		IP20
Degree of pollution		2 to IEC 60 664-1 (DIN VDE 0110/T1), no condensation permitted during operation
Strain resistance	• Stationary	Deflection Acceleration
	• Transport	Deflection Acceleration
Climatic category (during operation)		3K3 to IEC 60 721-3-3
Cooling method		Natural air cooling
Permissible ambient or cooling agent temperature		
• Operation		–10 °C to +50 °C (+14 °F to +122 °F)
• Storage and transport		–25 °C to +70 °C (–13 °F to +158 °F)
Relative humidity (permissible humidity rating)		
• Operation		≤ 85 % (non-condensing)
• Storage and transport		≤ 95 %
Electromagnetic compatibility	Emission	to EN 55 011 (1991) Class A
	Interference	to IEC 60 801-3 and EN 61 000-4-3
Power supply		6.5 V ± 5 %, max. 300 mA, internal from inverter or 24 V ± 10 %, max. 350 mA, external
Output voltage		5 V ± 10 %, max. 100 mA, galvanically isolated supply • for terminating the serial interface bus or • for supplying the OLP (Optical Link Plug)
Data transmission rate		max. 12 Mbaud

6.5 V ± 5 %, max. 300 mA internal from inverter or 24 V, max. 60 mA from DeviceNet-Bus
--

–

125, 250 and 500 Kbaud

MICROMASTER 430

Options

Variant independent options

Technical data of the communication modules (continued)

CANopen module
6SE6400-1CB00-0AA0



Size (height x width x depth)	161 mm x 73 mm x 46 mm
Degree of protection	IP20
Degree of pollution	2 to IEC 60664-1 (DIN VDE 0110/T1), no condensation permitted during operation
Strain resistance	to IEC 60068-2-6 (if module is installed correctly)
• Stationary	Deflection Acceleration 0.15 mm in the frequency range of 10 Hz to 58 Hz 19.6 m/s ² in the frequency range of 58 Hz to 500 Hz
• Transport	Deflection Acceleration 3.5 mm in the frequency range of 5 Hz to 9 Hz 9.8 m/s ² in the frequency range of 9 Hz to 500 Hz
Climatic category (during operation)	3K3 to IEC 60721-3-3
Cooling method	Natural air cooling
Permissible ambient or cooling agent temperature	
• Operation	–10 °C to +50 °C (+14 °F to +122 °F)
• Storage	–40 °C to +70 °C (–40 °F to +158 °F)
• Transport	–25 °C to +70 °C (–13 °F to +158 °F)
Relative humidity (permissible humidity rating)	
• Operation	≤ 85 % (non-condensing)
• Storage and transport	≤ 95 %
Power supply	The CAN bus is supplied from the inverter power supply
Data transmission rate	10, 20, 50, 125, 250, 500, 800 Kbaud and 1 Mbaud

Documentation

Selection and ordering data

Type of documentation	Language	Order No.
Docu pack , supplied with each inverter, containing DVD ¹⁾ and Getting Started Guide ²⁾ (paper version)	Multilanguage	6SE6400-5AD00-1AP1
Operating instructions (paper version)	German, English, French, Italian, Spanish Available as pdf file on the Internet at http://support.automation.siemens.com/WW/view/en/10804926/133300	
Parameter list (paper version)	German, English, French, Italian, Spanish Available as pdf file on the Internet at http://support.automation.siemens.com/WW/view/en/10804926/133300	

1) The DVD contains operating instructions, parameter list, commissioning tools STARTER and DriveMonitor, multilanguage.

Available on the Internet:
DriveMonitor at
<http://support.automation.siemens.com/WW/view/en/10804984/133100>

STARTER at
<http://support.automation.siemens.com/WW/view/en/10804985/133100>

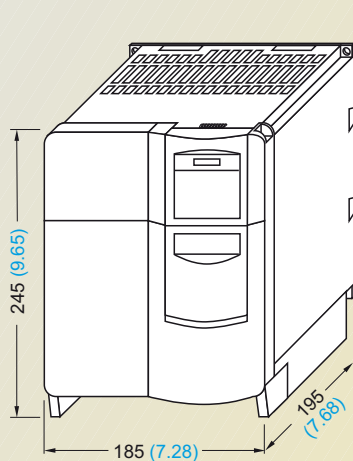
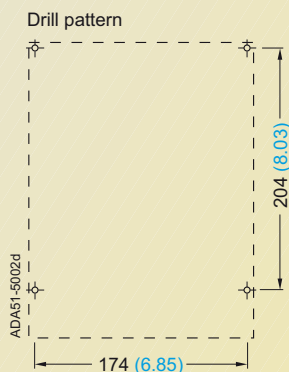
2) Available on the Internet at
<http://support.automation.siemens.com/WW/view/en/10804926/133300>

MICROMASTER 430 inverter

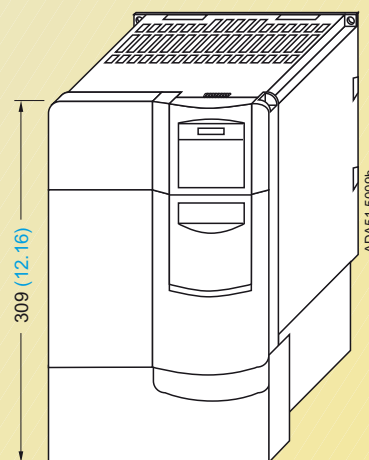
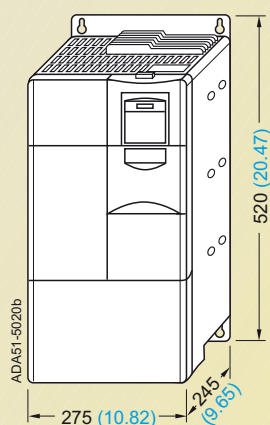
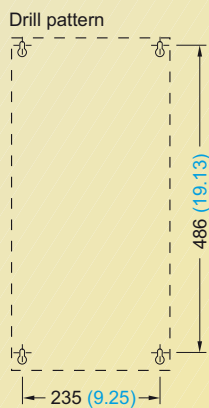
Frame size	3 AC 380 V to 480 V
C	7.5 kW to 15 kW
D	18.5 kW to 30 kW
E	37 kW to 45 kW

Note:

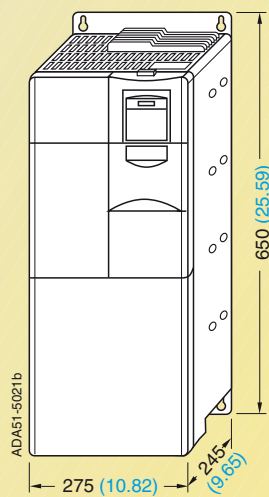
*The inverters must not be mounted horizontally.
But the inverters can be mounted without lateral spacing.*

Inverter frame size **C**

Fixing with
4 x M5 bolts
4 x M5 nuts
4 x M5 washers
Tightening torque with washers fitted:
3.0 Nm
Ventilation clearance required at top
and bottom: 100 mm

Inverter frame size **C**
with **gland plate**Inverter frame size **D**

Fixing with
4 x M8 bolts
4 x M8 nuts
4 x M8 washers
Tightening torque with
washers fitted: 13 Nm
Ventilation clearance
required at top and bottom:
300 mm

Inverter frame size **E**

Fixing with
4 x M8 bolts
4 x M8 nuts
4 x M8 washers
Tightening torque with
washers fitted: 13 Nm
Ventilation clearance
required at top and bottom:
300 mm

With the communication module, the mounting depth increases
for frame size C by 23 mm (0.91 inches).

All dimensions in mm (values in brackets are in inches)

MICROMASTER 430

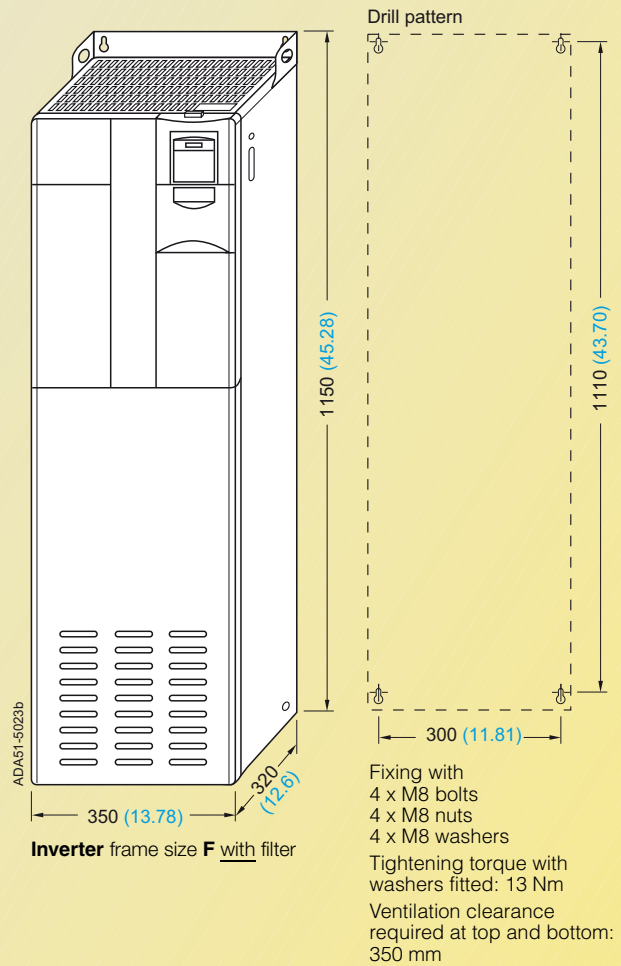
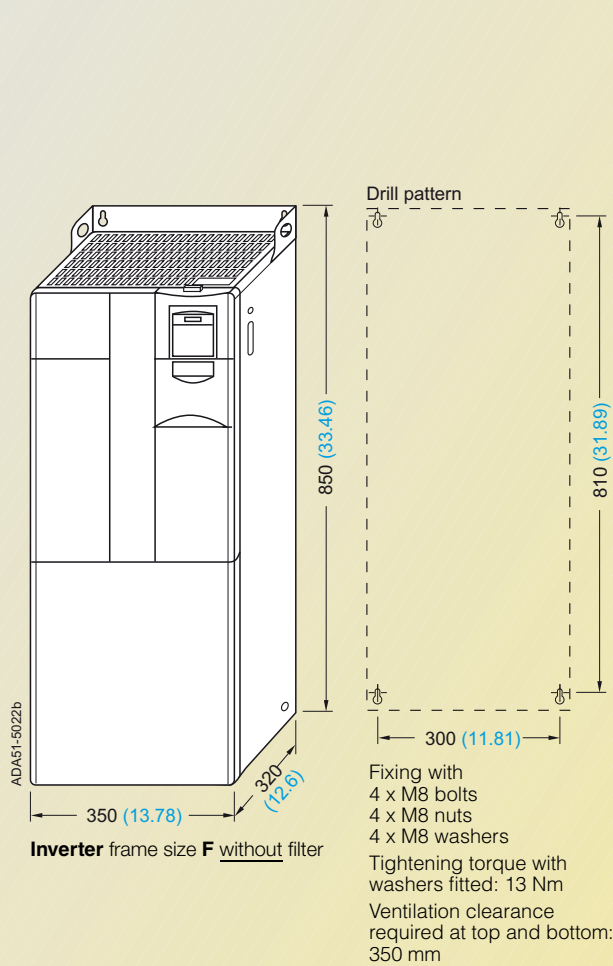
Dimension drawings

MICROMASTER 430 inverter

Frame size	3 AC 380 V to 480 V
F	55 kW to 90 kW

Note:

The inverters must not be mounted horizontally.
But the inverters can be mounted without lateral spacing.



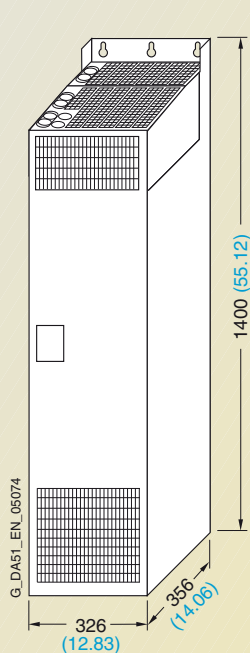
All dimensions in mm (values in brackets are in inches)

MICROMASTER 430 inverter

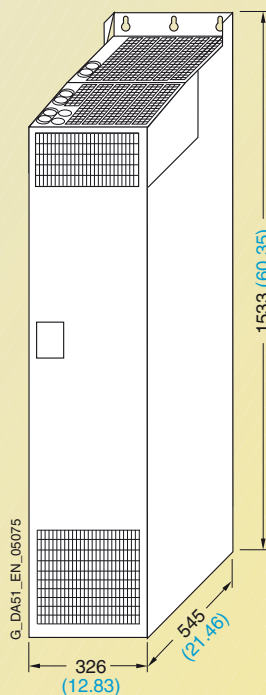
Frame size	3 AC 380 V to 480 V
FX	110 kW to 132 kW
GX	160 kW to 250 kW

Note:

*The inverters must not be mounted horizontally.
But the inverters can be mounted without lateral spacing.*

Inverter frame size **FX**

Fixing with
6 x M8 bolts
6 x M8 nuts
6 x M8 washers
Tightening torque
with washers
fitted: 13.0 Nm
Ventilation clearance
required:
at top: 250 mm
at bottom: 150 mm
in front: 40 mm

Inverter frame size **GX**

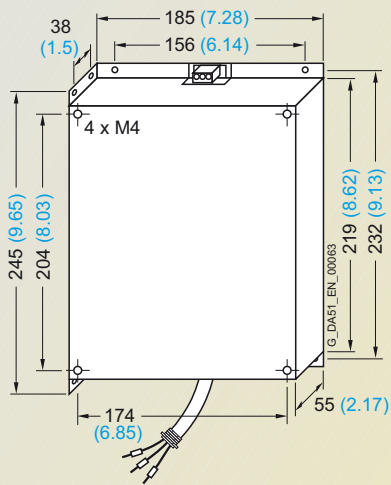
Fixing with
6 x M8 bolts
6 x M8 nuts
6 x M8 washers
Tightening torque
with washers
fitted: 13.0 Nm
Ventilation clearance
required:
at top: 250 mm
at bottom: 150 mm
in front: 50 mm

All dimensions in mm (values in brackets are in inches)

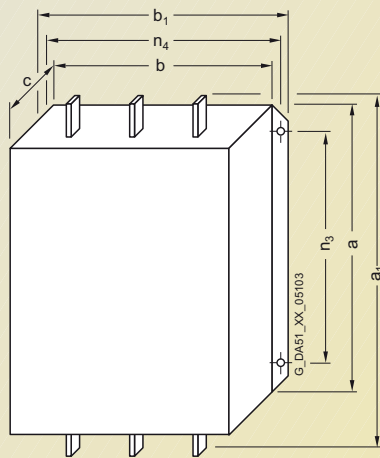
MICROMASTER 430

Dimension drawings

EMC filter



EMC filter for frame size **C**

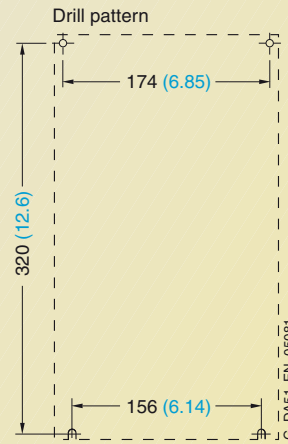
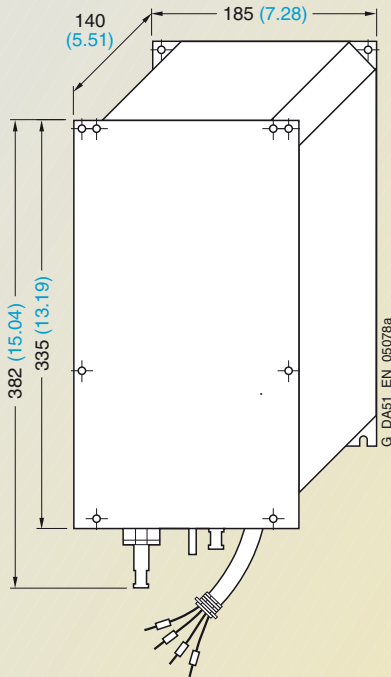


EMC filter Class A Type 6SL3000-	for inverter Frame size (FS)	Dimensions							Weight, approx. kg
		a	a ₁	b	b ₁	c	n ₃	n ₄	
OBE32-5AA0	FX	270 (10.63)	360 (14.17)	200 (7.87)	240 (9.45)	116 (4.57)	210 (8.27)	220 (8.66)	12.3
OBE34-4AA0	FX/GX	270 (10.63)	360 (14.17)	200 (7.87)	240 (9.45)	116 (4.57)	210 (8.27)	220 (8.66)	12.3
OBE36-0AA0	GX	310 (12.2)	400 (15.75)	215 (8.46)	265 (10.43)	140 (5.51)	250 (9.84)	240 (9.45)	19.0

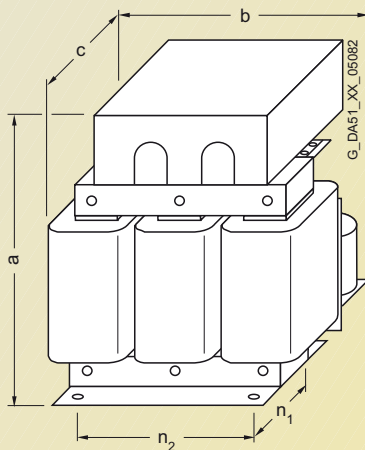
EMC filter for frame sizes **FX** and **GX**

All dimensions in mm (values in brackets are in inches)

LC filter



Fixing with M5 bolts

LC filter 6SE6400-3TD03-2CD0 for frame size **C**

Fixing with M10 bolts

LC filter for frame sizes **D to F**

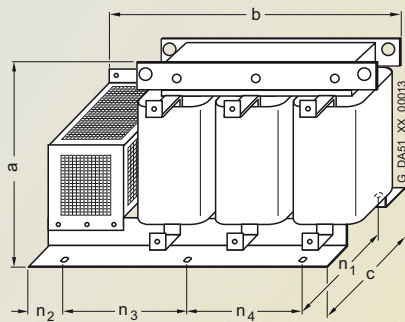
LC filter Type	for inverter Frame size (FS)	Dimensions					Weight (max.) kg
		a	b	c	n ₁	n ₂	
6SE6400-3TD03-7DD0	D	278 (10.94)	240 (9.45)	230 (9.06)	115 (4.53)	190 (7.48)	21.0
6SE6400-3TD04-8DD0	D	290 (11.42)	240 (9.45)	240 (9.45)	125 (4.92)	190 (7.48)	26.0
6SE6400-3TD06-1DD0	D	345 (13.58)	300 (11.81)	220 (8.66)	120 (4.72)	240 (9.45)	34.0
6SE6400-3TD07-2ED0	E	355 (13.98)	300 (11.81)	235 (9.25)	145 (5.71)	240 (9.45)	49.5
6SE6400-3TD11-5FD0	E/F	460 (18.11)	360 (14.17)	235 (9.25)	125 (4.92)	264 (10.39)	67.0
6SE6400-3TD15-0FD0	F	460 (18.11)	360 (14.17)	250 (9.84)	140 (5.51)	264 (10.39)	75.0
6SE6400-3TD18-0FD0	F	520 (20.47)	420 (16.54)	290 (11.42)	173 (6.81)	316 (12.44)	77.5

All dimensions in mm (values in brackets are in inches)

MICROMASTER 430

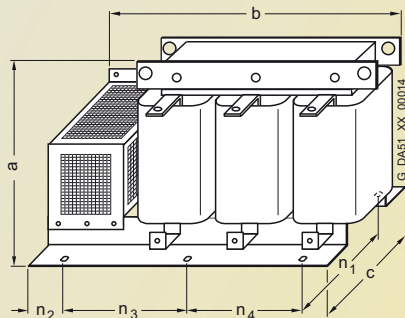
Dimension drawings

Sinusoidal filter



Sinusoidal filter for frame sizes **FX** and **GX**

Sinusoidal filter Type 6SL3000-	for inverter Frame size (FS)	Dimensions							Weight (max.) kg
		a	b	c	n ₁	n ₂	n ₃	n ₄	
2CE32-3AA0	FX	300 (11.81)	620 (24.41)	320 (12.6)	280 (11.02)	105 (4.13)	225 (8.86)	150 (5.91)	135.0
2CE32-8AA0	GX	300 (11.81)	620 (24.41)	320 (12.6)	280 (11.02)	105 (4.13)	225 (8.86)	150 (5.91)	138.0

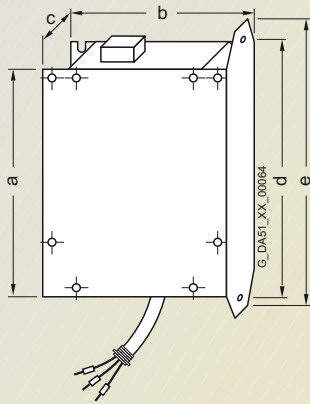


Sinusoidal filter for frame size **GX**

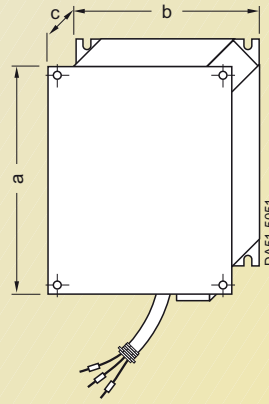
Sinusoidal filter Type 6SL3000-	for inverter Frame size (FS)	Dimensions							Weight (max.) kg
		a	b	c	n ₁	n ₂	n ₃	n ₄	
2CE33-3AA0	GX	370 (14.57)	620 (24.41)	360 (14.17)	320 (12.6)	105 (4.13)	225 (8.86)	150 (5.91)	144.0
2CE34-1AA0	GX	370 (14.57)	620 (24.41)	360 (14.17)	320 (12.6)	105 (4.13)	225 (8.86)	150 (5.91)	208.0

All dimensions in mm (values in brackets are in inches)

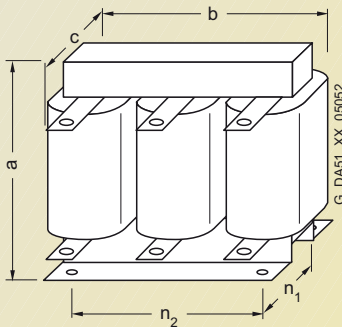
Line commutating chokes



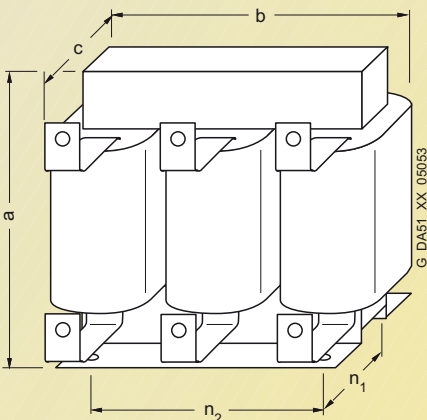
Line commutating choke for	Dimensions					Weight (max.) kg
	a	b	c	d	e	
Frame size C	245 (9.65)	185 (7.28)	50 (1.97)	264 (10.39)	280 (11.02)	5.1

Line commutating choke for frame size **C**

Line commutating choke for	Dimensions			Weight (max.) kg
	a	b	c	
Frame size D	520 (20.47)	275 (10.83)	85 (3.35)	9.5
Frame size E	650 (25.59)	275 (10.83)	95 (3.74)	17.0

Line commutating choke for frame sizes **D** and **E**Line commutating choke for inverter frame size **F**

Line commutating choke Type 6SE6400-	for inverter Frame size	Dimensions					Weight (max.) kg
		a	b	c	n ₁	n ₂	
3CC11-....	F	228 (8.98)	240 (9.45)	141 (5.55)	95 (3.74)	185 (7.28)	25.0

Line commutating choke for inverters of frame sizes **FX** and **GX**

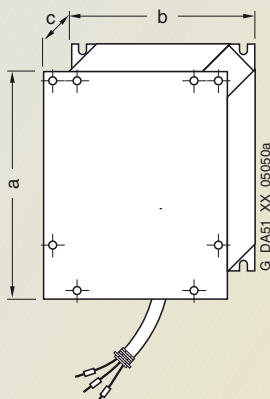
Line commutating choke Type 6SL3000-	for inverter Frame size (FS)	Dimensions					Weight (max.) kg
		a	b	c	n ₁	n ₂	
0CE32-....	FX	248 (9.76)	255 (10.04)	203 (7.99)	101 (3.98)	200 (7.87)	24.0
0CE33-....	GX	248 (9.76)	255 (10.04)	203 (7.99)	101 (3.98)	200 (7.87)	25.0
0CE35-....	GX	269 (10.59)	275 (10.83)	210 (8.27)	118 (4.65)	224 (8.82)	35.0

All dimensions in mm (values in brackets are in inches)

MICROMASTER 430

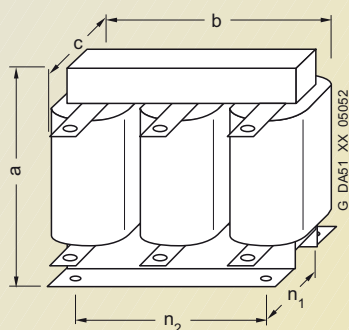
Dimension drawings

Output chokes



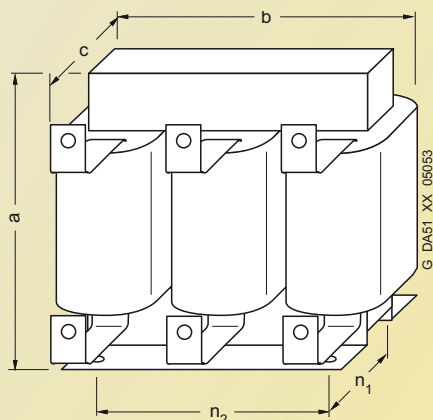
Line commutating choke
for frame size **C**

Output chokes for	Dimensions			Weight (max.) kg
	a	b	c	
Frame size C	245 (9.65)	185 (7.28)	80 (3.15)	6.6



Output chokes
for inverters of size **D, E and F**

Output choke Type 6SE6400-	for inverter Frame size (FS)	Dimensions			n ₁ (to DIN 41308)	n ₂	Weight (max.) kg
		a	b	c			
3TC03-8DD0	D	210 (8.27)	225 (8.86)	179 (7.05)	94 (3.70)	176 (6.93)	16.1
3TC05-4DD0	D	210 (8.27)	225 (8.86)	150 (5.91)	70 (2.76)	176 (6.93)	10.7
3TC07-5ED0	E	248 (9.76)	270 (10.63)	209 (8.23)	101 (3.98)	200 (7.87)	24.9
3TC08-0ED0	E	210 (8.27)	225 (8.86)	150 (5.91)	70 (2.76)	176 (6.93)	10.4
3TC14-5FD0	F	321 (12.64)	350 (13.78)	288 (11.34)	138 (5.43)	264 (10.39)	51.5
3TC15-4FD0	F	248 (9.76)	270 (10.63)	209 (8.23)	101 (3.98)	200 (7.87)	24.0



Output chokes
for inverters of size **FX and GX**

Output choke Type 6SL3000-	for inverter Frame size (FS)	Dimensions			n ₁	n ₂	Weight (max.) kg
		a	b	c			
2BE32-1AA0	FX	285 (11.22)	300 (11.81)	257 (10.12)	163 (6.42)	224 (8.82)	60.0
2BE32-6AA0	FX	315 (12.4)	300 (11.81)	277 (10.91)	183 (7.2)	224 (8.82)	66.0
2BE33-2AA0	GX	285 (11.22)	300 (11.81)	257 (10.12)	163 (6.42)	224 (8.82)	62.0
2BE33-8AA0	GX	285 (11.22)	300 (11.81)	277 (10.91)	183 (7.2)	224 (8.82)	73.0
2BE35-0AA0	GX	365 (14.37)	300 (11.81)	277 (10.91)	183 (7.2)	224 (8.82)	100.0

All dimensions in mm (values in brackets are in inches)

Inverter MICROMASTER 440



4/2	Description
4/4	Circuit diagrams
4/6	Technical data
4/9	Selection and ordering data
4/12	Options
4/26	Dimension drawings

MICROMASTER 440

Description



Application

The MICROMASTER 440 inverter is suitable for a variety of variable-speed drive applications. Its flexibility provides for a wide spectrum of applications. These also include cranes and hoisting gear, high-bay warehouses, production machines for food, beverages and tobacco, packaging machines etc.; i.e. applications which require the frequency inverter to have a higher functionality and dynamic response than usual.

The inverter is especially characterized by its customer-oriented performance and ease-of-use. Its large mains voltage range enables it to be used all over the world.

Design

The MICROMASTER 440 inverter has a modular design. The operator panels and modules can be easily exchanged.

International standards

- The MICROMASTER 440 inverter complies with the requirements of the EU low-voltage guideline
- The MICROMASTER 440 inverter has the **CE** marking
- acc. to **®** and **c®** certified
- c-tick **C**

Note:

- See Appendix for standards.

Main characteristics

- Easy, guided start-up
- Modular construction allows maximum configuration flexibility
- Six programmable isolated digital inputs
- Two scaleable analog inputs (0 V to 10 V, 0 mA to 20 mA) can also be used as a 7th/8th digital input
- Two programmable analog outputs (0 mA to 20 mA)
- Three programmable relay outputs (30 V DC/5 A resistive load; 250 V AC/2A inductive load)
- Low-noise motor operation thanks to high pulse frequencies, adjustable (observe derating if necessary)
- Complete protection for motor and inverter.
- Basic Operator Panel (BOP) for parameterizing the inverter
- Plain text Advanced Operator Panel (AOP) with multi-language display
- Plain text Asian Advanced Operator Panel (AAOP) with Chinese and English display
- Plain text Cyrillic Advanced Operator Panel (CAOP) with Cyrillic, German and English display
- Communication modules
 - PROFIBUS
 - DeviceNet
 - CANopen
- Pulse encoder evaluation module
- PC connection kits
- Mounting kits for installing the operator panels in the control cabinet doors
- PC start-up tools executable under Windows 98 and NT/2000/ME/XP Professional
- TIA integration with Drive ES.

Options (overview)

- EMC filter, Class A/B
- LC filter and sinusoidal filter
- Line commutating chokes
- Output chokes
- Gland plates

Mechanical features

- Modular design
- Operating temperature
0.12 kW to 75 kW:
-10 °C to +50 °C
(+14 °F to +122 °F)
90 kW to 200 kW:
0 °C to +40 °C
(+32 °F to +104 °F)
- Compact housing as a result of high power density
- Easy cable connection, mains and motor connections are separated for optimum electromagnetic compatibility
- Detachable operator panels
- Screwless control terminals on detachable I/O board.

Performance features

- Latest IGBT technology
- Digital microprocessor control
- High-quality Vector Control system
- Flux Current Control (FCC) for improved dynamic response and optimized motor control
- Linear V/f characteristic
- Quadratic V/f characteristic
- Multipoint characteristic (programmable V/f characteristic)
- Torque control
- Flying restart
- Slip compensation
- Automatic restart following mains failure or fault
- User-definable function blocks for logic and arithmetic operations
- Kinetic buffering
- Positioning ramp down
- High-grade PID controller for simple internal process control (autotuning)
- Programmable acceleration/deceleration, 0 s to 650 s
- Ramp smoothing
- Fast Current Limit (FCL) for trip-free operation
- Fast, repeatable digital input response time
- Fine adjustment using two high-resolution 10-bit analog inputs
- Compound braking for controlled rapid braking
- Integrated brake chopper (for 0.12 kW to 75 kW inverters)
- Four skip frequencies
- Removable "Y" capacitor for use on IT systems (with non-grounded mains supplies, the "Y" capacitor must be removed and an output choke installed).

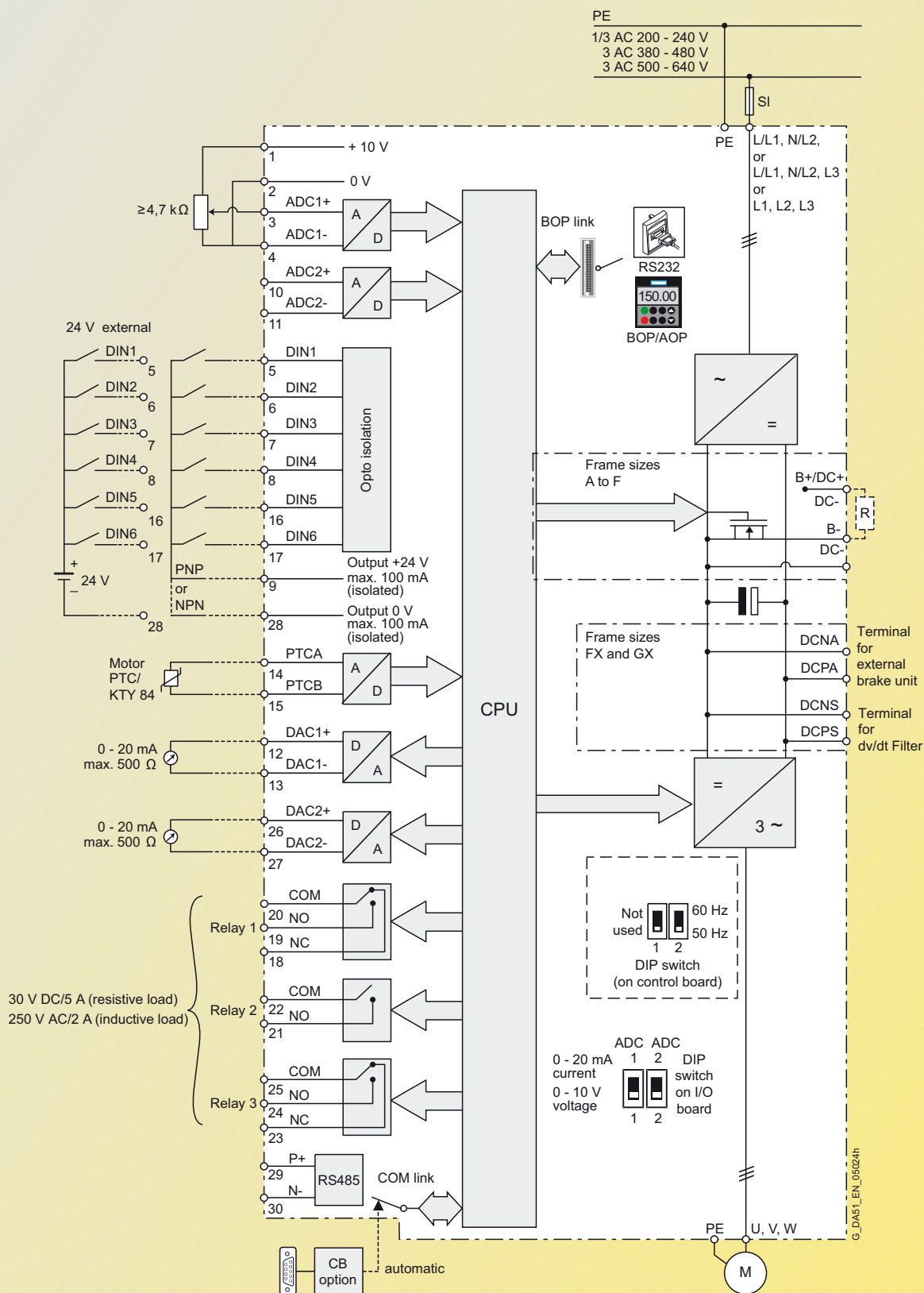
Protection features

- Overload capability
 - **CT mode**
0.12 kW to 75 kW:
Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 60 s, cycle time 300 s, and 2 x rated output current (i.e. 200 % overload capability) for 3 s, cycle time 300 s
90 kW to 200 kW:
Overload current 1.36 x rated output current (i.e. 136 % overload capability) for 57 s, cycle time 300 s, and 1.6 x rated output current (i.e. 160 % overload capability) for 3 s, cycle time 300 s
 - **VT mode**
5.5 kW to 90 kW:
Overload current 1.4 x rated output current (i.e. 140 % overload capability) for 3 s, and 1.1 x rated output current (i.e. 110 % overload capability) for 60 s, cycle time 300 s
110 kW to 250 kW:
Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 1 s, and 1.1 x rated output current (i.e. 110 % overload capability) for 59 s, cycle time 300 s
- Overvoltage/undervoltage protection
- Inverter overtemperature protection
- Special direct connection for PTC or KTY to protect the motor
- Earth fault protection
- Short-circuit protection
- $\hat{P}t$ motor thermal protection
- Locked motor protection
- Stall prevention
- Parameter interlock.

MICROMASTER 440

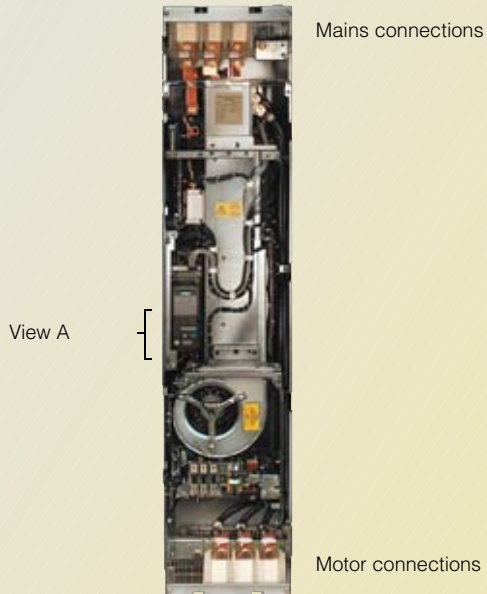
Circuit diagrams

General circuit diagram

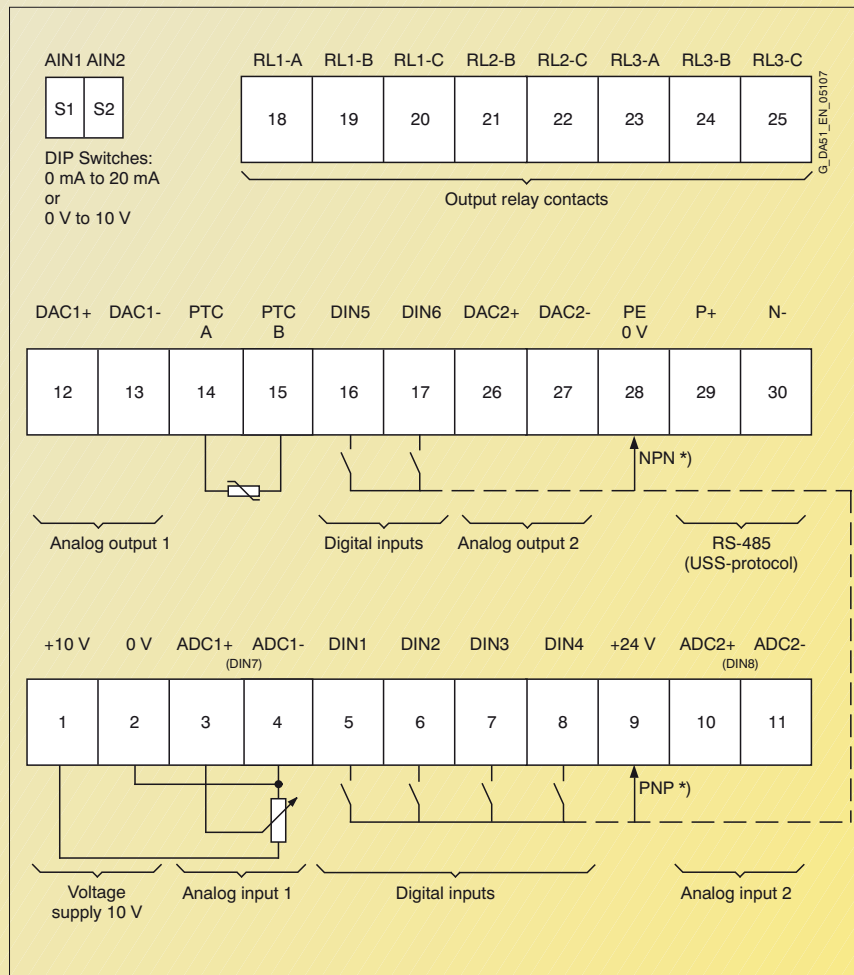


Terminal connection diagram

Example, frame size FX



View A



*) PNP or NPN possible

MICROMASTER 440

Technical data

MICROMASTER 440 inverter

Mains voltage and power ranges		1 AC 200 V to 240 V ± 10 %	CT (constant torque)	VT (variable torque)		
		3 AC 200 V to 240 V ± 10 %	0.12 kW to 3 kW	–		
		3 AC 380 V to 480 V ± 10 %	0.12 kW to 45 kW	5.5 kW to 55 kW		
		3 AC 500 V to 600 V ± 10 %	0.37 kW to 200 kW	7.5 kW to 250 kW		
		0.75 kW to 75 kW	1.5 kW to 90 kW			
Input frequency		47 Hz to 63 Hz				
Output frequency	0.12 kW to 75 kW	0 Hz to 650 Hz (in V/f mode) 0 Hz to 200 Hz (in vector mode)				
	90 kW to 200 kW	(Due to legal restrictions a limitation to 550 Hz is under preparation) 0 Hz to 267 Hz (in V/f mode) 0 Hz to 200 Hz (in vector mode)				
Power factor		≥ 0.95				
Inverter efficiency		0.12 kW to 75 kW: 96 % to 97 %; 90 kW to 200 kW: 97 % to 98 % (Further information is available on the Internet at: http://support.automation.siemens.com/WW/view/en/22978972)				
Overload capability – CT mode	0.12 kW to 75 kW	Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 60 s, cycle time 300 s and 2 x rated output current (i.e. 200 % overload capability) for 3 s, cycle time 300 s Overload current 1.36 x rated output current (i.e. 136 % overload capability) for 57 s, cycle time 300 s and 1.6 x rated output current (i.e. 160 % overload capability) for 3 s, cycle time 300 s Overload current 1.4 x rated output current (i.e. 140 % overload capability) for 3 s, and 1.1 x rated output current (i.e. 110 % overload capability) for 60 s, cycle time 300 s Overload current 1.5 x rated output current (i.e. 150 % overload capability) for 1 s, and 1.1 x rated output current (i.e. 110 % overload capability) for 59 s, cycle time 300 s				
	90 kW to 200 kW					
	– VT mode					
	5.5 kW to 90 kW					
	110 kW to 250 kW					
Inrush current		not higher than rated input current				
Control method		Vector control, torque control, linear V/f characteristic; quadratic V/f characteristic; Multipoint characteristic (programmable V/f characteristic); flux current control (FCC)				
Pulse frequency	0.12 kW to 75 kW	4 kHz (standard); 16 kHz (standard with 230 V inverters 0.12 kW to 5.5 kW)				
	90 kW to 200 kW	2 kHz to 16 kHz (in 2 kHz steps) 2 kHz (standard with VT mode); 4 kHz (standard with CT mode) 2 kHz to 4 kHz (in 2 kHz steps)				
Fixed frequencies		15, programmable				
Skip frequency ranges		4, programmable				
Setpoint resolution		0.01 Hz digital; 0.01 Hz serial; 10 bit analog				
Digital inputs		6 fully programmable isolated digital inputs; switchable PNP/NPN				
Analog inputs		2 programmable analog inputs • 0 V to 10 V, 0 mA to 20 mA and –10 V to +10 V (AIN1) • 0 V to 10 V and 0 mA to 20 mA (AIN2) • both can be used as 7th/8th digital input				
Relay outputs		3, programmable, 30 V DC/5 A (resistive load); 250 V AC/2A (inductive load)				
Analog outputs		2, programmable (0/4 mA to 20 mA)				
Serial interfaces		RS-485, optional RS-232				
Motor cable lengths	without output choke	0.12 – 75 kW: max. 50 m (shielded), max. 100 m (unshielded)				
	with output choke	90 – 250 kW: max. 200 m (shielded), max. 300 m (unshielded) see variant dependent options				
Electromagnetic compatibility (see Selection and Ordering Data)		EMC filter, Class A or Class B to EN 55 011 available as an option Inverter with internal filter Class A available				
Braking		Resistance braking with DC braking, compound braking, integrated brake chopper (integrated brake chopper only with 0.12 kW to 75 kW inverters)				
Degree of protection		IP20				
Operating temperature (without derating)	0.12 kW to 75 kW	CT: –10 °C to +50 °C (+14 °F to +122 °F)				
	90 kW to 200 kW	VT: –10 °C to +40 °C (+14 °F to +104 °F) 0 °C to +40 °C (+32 °F to +104 °F)				
Storage temperature		–40 °C to +70 °C (–40 °F to +158 °F)				
Relative humidity		95% (non-condensing)				
Installation altitude	0.12 kW to 75 kW	up to 1000 m above sea level without derating				
	90 kW to 200 kW	up to 2000 m above sea level without derating				
Standard SCCR (Short Circuit Current Rating) ¹⁾		FSA, FSB, FSC: 10 kA FSD, FSE, FSF, FSFX, FSGX: 65 kA				
Protection features for		Undervoltage, overvoltage, overload, earth faults, short-circuits, stall prevention, locked motor protection, motor over-temperature, inverter overtemperature, parameter change protection				
Compliance with standards		Ⓜ, cⓂ, CE, c-tick				
CE marking		Conformity with low-voltage directive 73/23/EEC				
Cooling-air volumetric flow required, dimensions and weights (without options)	Frame size (FS)	Cooling-air volumetric flow required (l/s)/(CFM)	H	x W	x D, max. (mm)	Weight, approx. (kg)
	A	4.8/10.2	173	x 73	x 149	1.3
	B	24/51	202	x 149	x 172	3.4
	C	54.9/116.3	245	x 185	x 195	5.7
	D	2 x 54.9/2 x 116.3	520	x 275	x 245	17
	E	2 x 54.9/2 x 116.3	650	x 275	x 245	22
	F without filter	150/317.79	850	x 350	x 320	56
	F with filter	150/317.79	1150	x 350	x 320	75
	FX	225/478.13	1400	x 326	x 356	116
	GX	440/935	1533	x 326	x 545	174
1) For footnote, see page 4/7.						

1) For footnote, see page 4/7.

CFM: Cubic Feet per Minute

Derating data

Pulse frequency

Output	Rated output current in A for a pulse frequency of						
kW	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz	14 kHz	16 kHz
Mains voltage 1/3 AC 200 V							
0.12 to 5.5	Values correspond to the 4 kHz standard values. No derating, since 16 kHz standard.						
7.5	28.0	26.6	25.2	22.4	19.6	16.8	14.0
11	42.0	37.8	33.6	29.4	25.2	21.0	16.8
15	54.0	48.6	43.2	37.8	32.4	27.0	21.6
18.5	68.0	64.6	61.2	54.4	47.6	40.8	34.0
22	80.0	72.0	64.0	56.0	48.0	40.0	32.0
30	104.0	91.0	78.0	70.2	62.4	57.2	52.0
37	130.0	113.8	97.5	87.8	78.0	71.5	65.0
45	154.0	134.8	115.5	104.0	92.4	84.7	77.0

Mains operating voltage 3 AC 400 V

0.37	1.3	1.3	1.3	1.3	1.3	1.2	1.0
0.55	1.7	1.7	1.7	1.6	1.5	1.4	1.2
0.75	2.2	2.2	2.2	2.0	1.8	1.5	1.3
1.1	3.1	2.9	2.8	2.5	2.2	1.9	1.6
1.5	4.1	3.7	3.3	2.9	2.5	2.1	1.6
2.2	5.9	5.6	5.3	4.7	4.1	3.5	3.0
3.0	7.7	6.9	6.2	5.4	4.6	3.9	3.1
4.0	10.2	9.2	8.2	7.1	6.1	5.1	4.1
5.5	13.2	11.9	10.6	9.2	7.9	6.6	5.3
7.5	19.0	18.1	17.1	15.2	13.3	11.4	9.5
11.0	26.0	23.4	20.8	18.2	15.6	13.0	10.4
15.0	32.0	30.4	28.8	25.6	22.4	19.2	16.0
18.5	38.0	34.2	30.4	26.6	22.8	19.0	15.2
22	45.0	40.5	36.0	31.5	27.0	22.5	18.0
30	62.0	58.9	55.8	49.6	43.4	37.2	31.0
37	75.0	67.5	60.0	52.5	45.0	37.5	30.0
45	90.0	76.5	63.0	51.8	40.5	33.8	27.0
55	110.0	93.5	77.0	63.3	49.5	41.3	33.0
75	145.0	112.4	79.8	68.9	58.0	50.8	43.5
90	178.0	–	–	–	–	–	–
110	205.0	–	–	–	–	–	–
132	250.0	–	–	–	–	–	–
160	302.0	–	–	–	–	–	–
200	370.0	–	–	–	–	–	–

Mains operating voltage 3 AC 500 V

0.75	1.4	1.2	1.0	0.8	0.7	0.6	0.6
1.5	2.7	2.2	1.6	1.4	1.1	0.9	0.8
2.2	3.9	2.9	2.0	1.6	1.2	1.0	0.8
4.0	6.1	4.6	3.1	2.4	1.8	1.5	1.2
5.5	9.0	6.8	4.5	3.6	2.7	2.3	1.8
7.5	11.0	8.8	6.6	5.5	4.4	3.9	3.3
11.0	17.0	12.8	8.5	6.8	5.1	4.3	3.4
15.0	22.0	17.6	13.2	11.0	8.8	7.7	6.6
18.5	27.0	20.3	13.5	10.8	8.1	6.8	5.4
22	32.0	24.0	16.0	12.8	9.6	8.0	6.4
30	41.0	32.8	24.6	20.5	16.4	14.4	12.3
37	52.0	39.0	26.0	20.8	15.6	13.0	10.4
45	62.0	52.7	43.4	40.3	37.2	32.6	27.9
55	77.0	67.4	57.8	52.0	46.2	42.4	38.5
75	99.0	84.2	69.3	64.4	59.4	52.0	44.6

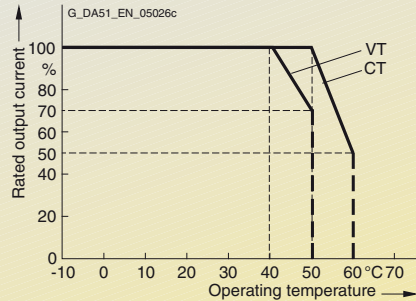
1) Applies to industrial control cabinet installations to NEC article 409/UL 508A.

Technical data

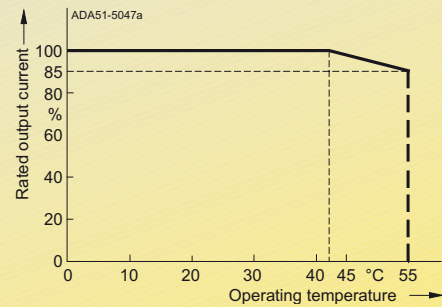
Derating data (continued)

Operating temperature

Inverter 0.12 kW to 75 kW



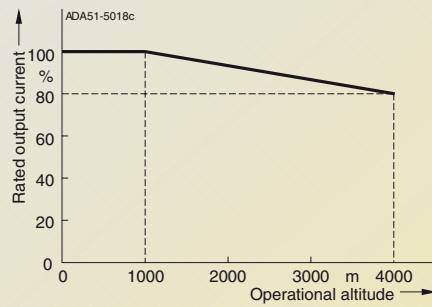
Inverter 90 kW to 200 kW



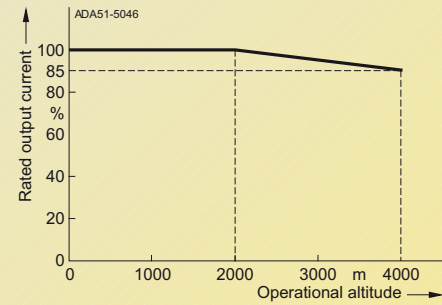
Installation altitude above sea level

Permissible output current
in % of the rated output current

Inverter 0.12 kW to 75 kW

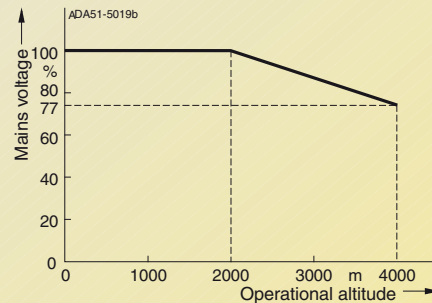


Inverter 90 kW to 200 kW

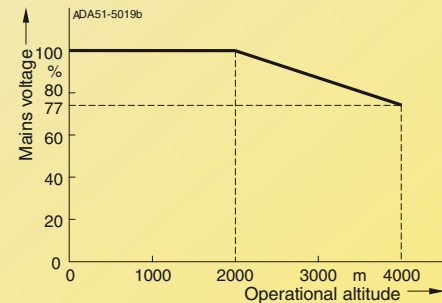


Permissible mains voltage
in % of the max. possible mains voltage

Inverter 0.12 kW to 75 kW



Inverter 90 kW to 200 kW



MICROMASTER 440 inverter without filter²⁾

CT (constant torque)				VT (variable torque)				MICROMASTER 440 without filter ²⁾		
Output		Rated input	Rated output	Output		Rated input	Rated output	Frame	Weight,	Order No.
kW	hp	current ¹⁾	current	kW	hp	current ¹⁾	current	size	approx.	
		A	A			A	A	(FS)	kg	
Mains voltage 1 AC 200 V to 240 V										
0.12	0.16	1.8	0.9	–	–	–	–	A	1.3	6SE6440-2UC11-2AA1
0.25	0.33	3.2	1.7	–	–	–	–	A	1.3	6SE6440-2UC12-5AA1
0.37	0.50	4.6	2.3	–	–	–	–	A	1.3	6SE6440-2UC13-7AA1
0.55	0.75	6.2	3.0	–	–	–	–	A	1.3	6SE6440-2UC15-5AA1
0.75	1.0	8.2	3.9	–	–	–	–	A	1.3	6SE6440-2UC17-5AA1
1.1	1.5	11.0	5.5	–	–	–	–	B	3.3	6SE6440-2UC21-1BA1
1.5	2	14.4	7.4	–	–	–	–	B	3.3	6SE6440-2UC21-5BA1
2.2	3	20.2	10.4	–	–	–	–	B	3.3	6SE6440-2UC22-2BA1
3.0	4	35.5	13.6	–	–	–	–	C	5.5	6SE6440-2UC23-0CA1
Mains operating voltage 3 AC 200 V to 240 V										
0.12	0.16	1.1	0.9	–	–	–	–	A	1.3	6SE6440-2UC11-2AA1
0.25	0.33	1.9	1.7	–	–	–	–	A	1.3	6SE6440-2UC12-5AA1
0.37	0.50	2.7	2.3	–	–	–	–	A	1.3	6SE6440-2UC13-7AA1
0.55	0.75	3.6	3.0	–	–	–	–	A	1.3	6SE6440-2UC15-5AA1
0.75	1.0	4.7	3.9	–	–	–	–	A	1.3	6SE6440-2UC17-5AA1
1.1	1.5	6.4	5.5	–	–	–	–	B	3.3	6SE6440-2UC21-1BA1
1.5	2.0	8.3	7.4	–	–	–	–	B	3.3	6SE6440-2UC21-5BA1
2.2	3.0	11.7	10.4	–	–	–	–	B	3.3	6SE6440-2UC22-2BA1
3.0	4.0	15.6	13.6	–	–	–	–	C	5.5	6SE6440-2UC23-0CA1
4.0	5.0	19.7	17.5	5.5	7.5	28.3	22	C	5.5	6SE6440-2UC24-0CA1
5.5	7.5	26.5	22	7.5	10	34.2	28	C	5.5	6SE6440-2UC25-5CA1
7.5	10	34.2	28	11.0	15	38.0	42	D	16	6SE6440-2UC27-5DA1
11.0	15	38.0	42	15.0	20	50.0	54	D	16	6SE6440-2UC31-1DA1
15.0	20	50.0	54	18.5	25	62.0	68	D	16	6SE6440-2UC31-5DA1
18.5	25	62.0	68	22	30	71.0	80	E	20	6SE6440-2UC31-8EA1
22	30	71.0	80	30	40	96.0	104	E	20	6SE6440-2UC32-2EA1
30	40	96.0	104	37	50	114.0	130	F	55	6SE6440-2UC33-0FA1
37	50	114.0	130	45	60	135.0	154	F	55	6SE6440-2UC33-7FA1
45	60	135.0	154	55	75	164.0	178	F	55	6SE6440-2UC34-5FA1
Mains operating voltage 3 AC 380 V to 480 V										
0.37	0.50	2.2	1.3	–	–	–	–	A	1.3	6SE6440-2UD13-7AA1
0.55	0.75	2.8	1.7	–	–	–	–	A	1.3	6SE6440-2UD15-5AA1
0.75	1.0	3.7	2.2	–	–	–	–	A	1.3	6SE6440-2UD17-5AA1
1.1	1.5	4.9	3.1	–	–	–	–	A	1.3	6SE6440-2UD21-1AA1
1.5	2.0	5.9	4.1	–	–	–	–	A	1.3	6SE6440-2UD21-5AA1
2.2	3.0	7.5	5.9	–	–	–	–	B	3.3	6SE6440-2UD22-2BA1
3.0	4.0	10.0	7.7	–	–	–	–	B	3.3	6SE6440-2UD23-0BA1
4.0	5.0	12.8	10.2	–	–	–	–	B	3.3	6SE6440-2UD24-0BA1
5.5	7.5	15.6	13.2	7.5	10	17.3	19	C	5.5	6SE6440-2UD25-5CA1
7.5	10	22.0	18.4	11.0	15	23.1	26	C	5.5	6SE6440-2UD27-5CA1
11.0	15	23.1	26	15.0	20	33.8	32	C	5.5	6SE6440-2UD31-1CA1
15.0	20	33.8	32	18.5	25	37.0	38	D	16	6SE6440-2UD31-5DA1
18.5	25	37.0	38	22	30	43.0	45	D	16	6SE6440-2UD31-8DA1
22	30	43.0	45	30	40	59.0	62	D	16	6SE6440-2UD32-2DA1
30	40	59.0	62	37	50	72.0	75	E	20	6SE6440-2UD33-0EA1
37	50	72.0	75	45	60	87.0	90	E	20	6SE6440-2UD33-7EA1
45	60	87.0	90	55	75	104.0	110	F	56	6SE6440-2UD34-5FA1
55	75	104.0	110	75	100	139.0	145	F	56	6SE6440-2UD35-5FA1
75	100	139.0	145	90	125	169.0	178	F	56	6SE6440-2UD37-5FA1

1) Supplementary conditions:
Input current at rated operating point, applicable at short-circuit voltage of the supply $U_{sc} = 2\%$ with reference to the inverter rated power and rated mains operating voltage of 240 V or 400 V without a line commutating choke.

2) Acc. to EMC EN 61800-3 generally suited to heavy industrial applications. For details please refer to Appendix on page A/4.

MICROMASTER 440

Selection and ordering data

MICROMASTER 440 inverter without filter³⁾ (continued)

CT (constant torque)				VT (variable torque)				MICROMASTER 440 without filter ³⁾		
Output		Rated input current	Rated output current	Output		Rated input current	Rated output current	Frame size	Weight, approx.	Order No.
kW	hp	A	A	kW	hp	A	A	(FS)	kg	
Mains operating voltage 3 AC 380 V to 480 V										
90	125	169.0 ¹⁾	178	110	150	200.0 ¹⁾	205	FX	116	6SE6440-2UD38-8FA1
110	150	200.0 ¹⁾	205	132	200	245.0 ¹⁾	250	FX	116	6SE6440-2UD41-1FA1
132	200	245.0 ¹⁾	250	160	250	297.0 ¹⁾	302	GX	174	6SE6440-2UD41-3GA1
160	250	297.0 ¹⁾	302	200	300	354.0 ¹⁾	370	GX	174	6SE6440-2UD41-6GA1
200	300	354.0 ¹⁾	370	250	350	442.0 ¹⁾	477	GX	174	6SE6440-2UD42-0GA1
Mains operating voltage 3 AC 500 V to 600 V										
0.75	1.0	2.0 ²⁾	1.4	1.5	2.0	3.2 ²⁾	2.7	C	5.5	6SE6440-2UE17-5CA1
1.5	2.0	3.7 ²⁾	2.7	2.2	3.0	4.4 ²⁾	3.9	C	5.5	6SE6440-2UE21-5CA1
2.2	3.0	5.3 ²⁾	3.9	4.0	5.0	6.9 ²⁾	6.1	C	5.5	6SE6440-2UE22-2CA1
4.0	5.0	8.1 ²⁾	6.1	5.5	7.5	9.4 ²⁾	9	C	5.5	6SE6440-2UE24-0CA1
5.5	7.5	11.1 ²⁾	9	7.5	10	12.6 ²⁾	11	C	5.5	6SE6440-2UE25-5CA1
7.5	10	14.4 ²⁾	11	11.0	15	18.1 ²⁾	17	C	5.5	6SE6440-2UE27-5CA1
11.0	15	21.5 ²⁾	17	15.0	20	24.9 ²⁾	22	C	5.5	6SE6440-2UE31-1CA1
15.0	20	24.9 ²⁾	22	18.5	25	30.0 ²⁾	27	D	16	6SE6440-2UE31-5DA1
18.5	25	30.0 ²⁾	27	22	30	35.0 ²⁾	32	D	16	6SE6440-2UE31-8DA1
22	30	35.0 ²⁾	32	30	40	48.0 ²⁾	41	D	16	6SE6440-2UE32-2DA1
30	40	48.0 ²⁾	41	37	50	58.0 ²⁾	52	E	20	6SE6440-2UE33-0EA1
37	50	58.0 ²⁾	52	45	60	69.0 ²⁾	62	E	20	6SE6440-2UE33-7EA1
45	60	69.0 ²⁾	62	55	75	83.0 ²⁾	77	F	56	6SE6440-2UE34-5FA1
55	75	83.0 ²⁾	77	75	100	113.0 ²⁾	99	F	56	6SE6440-2UE35-5FA1
75	100	113.0 ²⁾	99	90	120	138.0 ²⁾	125	F	56	6SE6440-2UE37-5FA1



See Appendix for note on ordering.

All MICROMASTER 440 inverters are supplied with a Status Display Panel (SDP). A BOP, AOP or other options have to be ordered separately (see Pages 4/16 to 4/22).

Motors for MICROMASTER 440

Catalog D 81.1 contains selection and ordering data for motors which are particularly suitable for operation with the MICROMASTER 440 inverters (see Appendix for overview).

This catalog is suitable for IEC motors. For motors according to US standards (NEMA) please refer to Catalog D 81.2 U.S./Canada (see Appendix for overview) and to: <http://www.sea.siemens.com/motors>

1) Supplementary conditions:
Input current at rated operating point, applicable at short-circuit voltage of the supply $U_{sc} \geq 2.33\%$ with reference to the inverter rated power and rated mains operating voltage of 400 V.

2) Supplementary conditions:
Input current at rated operating point, applicable at short-circuit voltage of the supply $U_{sc} = 2\%$ with reference to the inverter rated power and rated mains operating voltage of 500 V without a line commutating choke.

3) Acc. to EMC EN 61800-3 generally suited to heavy industrial applications. For details please refer to Appendix on page A/4.

MICROMASTER 440 inverter with internal filter Class A ²⁾

CT (constant torque)				VT (variable torque)				MICROMASTER 440 with internal filter Class A ²⁾		
Output kW	hp	Rated input current ¹⁾ A	Rated output current A	Output kW	hp	Rated input current ¹⁾ A	Rated output current A	Frame size (FS)	Weight, approx. kg	Order No.
Mains operating voltage 1 AC 200 V to 240 V										
0.12	0.16	1.8	0.9	–	–	–	–	A	1.3	6SE6440-2AB11-2AA1
0.25	0.33	3.2	1.7	–	–	–	–	A	1.3	6SE6440-2AB12-5AA1
0.37	0.50	4.6	2.3	–	–	–	–	A	1.3	6SE6440-2AB13-7AA1
0.55	0.75	6.2	3.0	–	–	–	–	A	1.3	6SE6440-2AB15-5AA1
0.75	1.0	8.2	3.9	–	–	–	–	A	1.3	6SE6440-2AB17-5AA1
1.1	1.5	11.0	5.5	–	–	–	–	B	3.4	6SE6440-2AB21-1BA1
1.5	2	14.4	7.4	–	–	–	–	B	3.4	6SE6440-2AB21-5BA1
2.2	3	20.2	10.4	–	–	–	–	B	3.4	6SE6440-2AB22-2BA1
3.0	4	35.5	13.6	–	–	–	–	C	5.7	6SE6440-2AB23-0CA1
Mains operating voltage 3 AC 200 V to 240 V										
3.0	4.0	15.6	13.6	–	–	–	–	C	5.7	6SE6440-2AC23-0CA1
4.0	5.0	19.7	17.5	5.5	7.5	28.3	22	C	5.7	6SE6440-2AC24-0CA1
5.5	7.5	26.5	22.0	7.5	10.0	34.2	28	C	5.7	6SE6440-2AC25-5CA1
Mains operating voltage 3 AC 380 V to 480 V										
2.2	3.0	7.5	5.9	–	–	–	–	B	3.4	6SE6440-2AD22-2BA1
3.0	4.0	10.0	7.7	–	–	–	–	B	3.4	6SE6440-2AD23-0BA1
4.0	5.0	12.8	10.2	–	–	–	–	B	3.4	6SE6440-2AD24-0BA1
5.5	7.5	15.6	13.2	7.5	10	17.6	19	C	5.7	6SE6440-2AD25-5CA1
7.5	10	22.0	18.4	11.0	15	23.1	26	C	5.7	6SE6440-2AD27-5CA1
11.0	15	23.1	26	15.0	20	33.8	32	C	5.7	6SE6440-2AD31-1CA1
15.0	20	33.8	32	18.5	25	37.0	38	D	17	6SE6440-2AD31-5DA1
18.5	25	37.0	38	22	30	43.0	45	D	17	6SE6440-2AD31-8DA1
22	30	43.0	45	30	40	59.0	62	D	17	6SE6440-2AD32-2DA1
30	40	59.0	62	37	50	72.0	75	E	22	6SE6440-2AD33-0EA1
37	50	72.0	75	45	60	87.0	90	E	22	6SE6440-2AD33-7EA1
45	60	87.0	90	55	75	104.0	110	F	75	6SE6440-2AD34-5FA1
55	75	104.0	110	75	100	139.0	145	F	75	6SE6440-2AD35-5FA1
75	100	139.0	145	90	125	169.0	178	F	75	6SE6440-2AD37-5FA1



See Appendix for note on ordering.

All MICROMASTER 440 inverters are supplied with a Status Display Panel (SDP). A BOP, AOP or other options have to be ordered separately (see Pages 4/16 to 4/22).

Motors for MICROMASTER 440

Catalog D 81.1 contains selection and ordering data for motors which are particularly suitable for operation with the MICROMASTER 440 inverters (see Appendix for overview).

This catalog is suitable for IEC motors. For motors according to US standards (NEMA) please refer to Catalog D 81.2 U.S./Canada (see Appendix for overview) and to: <http://www.sea.siemens.com/motors>

1) Supplementary conditions:
Input current at rated operating point, applicable at short-circuit voltage of the supply $U_{sc} = 2\%$ with reference to the inverter rated power and rated mains operating voltage of 240 V or 400 V without a line commutating choke.

2) Use of MICROMASTER inverters with internal filter is not permissible on non-grounded mains supplies.

MICROMASTER 440

Options

Variant dependent options

Overview

EMC filter, Class A

Filter for inverters without an internal filter for

- 3 AC 200 V to 240 V, frame sizes A and B
- 3 AC 380 V to 480 V, frame size A, FX, GX

Filters for frame sizes FX and GX are only permitted to be used in combination with a line commutating choke.

All other inverters with the exception of inverters for 500 V to 600 V can be supplied with an internal Class A filter.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

EMC filter, Class B

Filter for inverters without an internal filter for

- 3 AC 200 V to 240 V, frame sizes A and B
- 3 AC 380 V to 480 V, frame size A.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

For inverters 15 kW to 75 kW without filters, EMC filters of Class B from Schaffner can be used.

The requirements are fulfilled using shielded cables with a max. length of 25 m to 50 m (depending on the type, details on request).

With this filter, the inverter complies with the emission standard EN 55 011, Class B for conducted interference emissions.

Additional EMC filter, Class B

Available for inverters with an internal Class A EMC filter, frame sizes A, B and C.

The requirements are fulfilled using shielded cables with a max. length of 25 m.

With this filter, the inverter complies with the emission standard EN 55 011, Class B for conducted interference emissions.

Filter Class B with low leakage currents

EMC filter for 1 AC 200 V to 240 V inverters, frame sizes A and B, without an internal EMC filter Class A.

With this filter, the inverter complies with the emission standard EN 55 011, Class B for conducted interference emissions. The leakage currents are reduced to < 3.5 mA.

The requirements are fulfilled using shielded cables with a max. length of 5 m.

Leakage currents:

The leakage currents of the inverters with/without filter (internal/external) may exceed 30 mA. Typical values in practice are between 10 mA and 50 mA. The exact values depend on the design, environment and cable lengths. Interference-free operation with residual current operated devices with a trigger value of 30 mA cannot be guaranteed. However, operation with residual current circuit-breakers with a trigger value of 300 mA is possible. Please refer to the Instruction Manual for details.

LC filter and sinusoidal filter

The LC filter/sinusoidal filter limits the rate of rise of voltage and the capacitive charge/discharge currents which usually occur with inverter operation. This means that much longer shielded motor cables are possible when using LC filters/sinusoidal filters and the service life of the motor achieves values similar to those with direct mains operation. Use of an output choke isn't required with that.

Please note when using LC filters/sinusoidal filters:

- Only V/f, FCC control permissible
- Please observe the derating of 15 % when selecting the appropriate inverter
- Operation only permissible with 4 kHz pulse frequency
Note: Please observe derating for frame sizes FX and GX.
- The output frequency is limited to 150 Hz
- Operation and commissioning only with connected motor as the LC filter/sinusoidal filter is not idling-proof!

The LC filters/sinusoidal filters can be used for all MICRO-MASTER 440 inverters of frame sizes A to GX.

- Frame sizes D to F:
The LC filters, frame sizes D to F, are designed for mounting upright in the control cabinet. Due to leakage flux lines caused by physical sources, a minimum distance of 50 mm to adjacent modules and metal parts is recommended.
- Frame sizes FX and GX:
The sinusoidal filters, frame sizes FX and GX, are designed for mounting upright in the control cabinet. Due to leakage flux lines caused by physical sources, a minimum distance of 100 mm to adjacent modules and metal parts is recommended.

Technical data

LC filter and sinusoidal filter

Mains voltage	3 AC 380 V to 480 V	3 AC 500 V to 600 V
Current (at 40 °C/50 °C)		
For frame size A (0.37 to 1.5 kW)	4.5 A/4.1 A	–
For frame size B (2.2 to 4 kW)	11.2 A/10.2 A	–
For frame size C (0.75 to 4 kW)	–	9.0 A/6.1 A
For frame size C (5.5 to 11 kW)	32.6 A/26 A	22.4 A/17 A
For frame size D (15 kW)	38.8 A/32 A	27.5 A/22 A
For frame size D (18.5 kW)	45.9 A/38 A	32.6 A/27 A
For frame size D (22 kW)	63.2 A/45 A	41.8 A/32 A
For frame size E (30 kW)	76.5 A/62 A	53 A/41 A
For frame size E (37 kW)	112.2 A/90 A	63.2 A/52 A
For frame size F (45 kW)	112.2 A/90 A	78.5 A/62 A
For frame size F (55 kW)	147.9 A/110 A	101 A/77 A
For frame size F (75 kW)	181.6 A/145 A	127.5 A/99 A
Current (at 40 °C/55 °C)		
For frame size FX (90 kW and 110 kW)	225 A/191 A	–
For frame size GX (132 kW)	276 A/235 A	–
For frame size GX (160 kW)	333 A/283 A	–
For frame size GX (200 kW)	408 A/347 A	–

Technical data (continued)**LC filter and sinusoidal filter**

Limiting of motor overvoltage			≤ 1078 V	
dV/dt limiting			≤ 500 V/ μ s	
Pulse frequency			4 kHz	
Max. motor frequency			150 Hz	
Max. permissible motor cable lengths				
For frame sizes A to F		shielded	200 m	
		unshielded	300 m	
For frame sizes FX and GX		shielded	300 m	
		unshielded	450 m	
Insulation strength			Overvoltage category III to VDE 0110	
Electromagnetic compatibility				
For frame sizes A to F			Up to 200 m motor cable length with emissions to Class A according to EN 55 011 in conjunction with filtered inverters and unshielded cables	
For frame sizes FX and GX			Up to 150 m motor cable length with emissions to Class A according to EN 55 011 in conjunction with filtered inverters and unshielded cables	
Conformity			CE according to the low-voltage directive 73/23/EEC	
Approvals			cUL E 219022	
Strain resistance			EN 60 068-2-31	
Humidity			95 % humidity, non-condensing	
Degree of protection				
For frame sizes A to C			IP20 (to EN 60 529)	
For frame sizes D to F			IP00/IP20 (to EN 60 529 with terminal covers)	
For frame sizes FX and GX			IP00	
Insulation class			H (180 °C)	
Temperature range				
For frame sizes A to F		Operation	–10 °C to +40 °C (+14 °F to +104 °F) to +50 °C (to +122 °F)	100 % P_n 80 % P_n
		Storage	–25 °C to +70 °C (–13 °F to +158 °F)	
For frame sizes FX and GX		Operation	–10 °C to +40 °C (+14 °F to +104 °F) to +55 °C (to +131 °F)	100 % P_n 85 % P_n
		Storage	–40 °C to +70 °C (–40 °F to +158 °F)	
Installation altitude				
For frame sizes A to C			Up to 2000 m:	100 % P_n
			2000 to 4000 m:	62.5 % P_n
For frame sizes D to F			Up to 1000 m:	100 % P_n
			1000 to 4000 m:	12.5 % derating for each 1000 m
For frame sizes FX and GX			Up to 2000 m:	100 % P_n
			2000 to 4000 m:	7.5 % derating for each 1000 m
Mounting position				
For frame sizes A to C			Footprint or suspended	
For frame sizes D to F, FX and GX			upright	
Ventilation clearances				
For frame sizes A to C		Top	100 mm	
		Bottom	100 mm	
		Side	100 mm	
For frame sizes D to F, FX and GX		Top	100 mm	
		Side	100 mm	
Connection system		Input, litz wire or terminal	1U1, 1V1, 1W1	
		Output, terminals	1U2, 1V2, 1W2	
Torque for conductor connections			Terminal cross-section	Torque
For frame sizes A to C			–	1.5 Nm to 1.8 Nm
For frame sizes D to F			16 mm ²	2.0 Nm to 4.0 Nm
			35 mm ²	2.5 Nm to 5.0 Nm
			50 mm ²	3.0 Nm to 6.0 Nm
			95 mm ²	6.0 Nm to 12.0 Nm
			150 mm ²	10.0 Nm to 20.0 Nm
For frame sizes FX and GX			–	14.0 Nm to 31.0 Nm
Weight, approx.				
For frame size A			7 kg	
For frame size B			11 kg	
For frame size C			8.5 kg to 29 kg	
For frame size D			21 kg to 42 kg	
For frame size E			49.5 kg to 67 kg	
For frame size F			67 kg to 126 kg	
For frame size FX			135 kg	
For frame size GX			138 kg to 208 kg	

MICROMASTER 440

Options

Variant dependent options

Overview

Line commutating choke

Line commutating chokes are used to smooth voltage peaks or to bridge commutating dips. In addition, line commutating chokes reduce the effects of harmonics on the inverter and the power supply. If the line impedance is $< 1\%$, a line commutating choke must be used in order to reduce the current peaks.

In line with EN 61 000-3-2 regulations "Limits for harmonic currents with device input current ≤ 16 A per phase", there are special aspects for drives with 250 W to 550 W and 230 V single-phase supplies which can be used in non-industrial applications (1st environment).

For devices with 250 W and 350 W, it is necessary either to fit the recommended input chokes or to apply to the power utility company for authorization to connect the devices to the public power supply.

No limits are currently defined in the EN 61 000-3-2 standard for professionally used devices with a connected load > 1 kW which means that the inverters with an output power ≥ 0.75 kW comply with the EN 61 000-3-2 standard.

However, in accordance with the regulations of EN 61000-3-12 "Limits for harmonic currents > 16 A and ≤ 75 A per phase" an approval is necessary from the power supplier for drives that are intended to be connected to the public low-voltage network. Please refer to the Operating Instructions for the values of the harmonic currents.

Output choke

Output chokes can be supplied for reducing the capacitive compensation currents and dV/dt in the case of motor cables > 50 m (shielded) or > 100 m (unshielded).

For max. permissible cable lengths, see the Technical Data.

Brake resistors

The brake resistors are designed for use with the MICROMASTER 440 inverter series, frame sizes A to F, with internal brake chopper and enable loads with a large moment of inertia to be braked quickly. During braking of the motor and the load, excess energy is fed back to the inverter. This causes the voltage to rise in the DC link. The inverter transfers the excess energy to the externally mounted braking resistor.

For MICROMASTER 440 inverters of frame sizes FX and GX, external SIMOVERT MASTERDRIVES brake units and the appropriate brake resistors can be used (see Catalog DA 65.10).

Gland plate

Gland plates are available for inverters of frame sizes A, B and C. All the other frame sizes have the shield connection for the control cable integrated in the inverter.

The shield for the power cable has to be connected externally (e.g. in the control cabinet). Exception: Inverters of frame sizes D and E and frame size F with integrated class A filter. In this case the shield connection is integrated in the inverter.

The gland plate enables the shields of the power and control cables to be terminated ensuring optimum EMC performance.

Technical data

Max. permissible cable lengths from the motor to the inverter when using output chokes

The following table shows the maximum permissible cable lengths from the motor to the inverter when using output chokes.

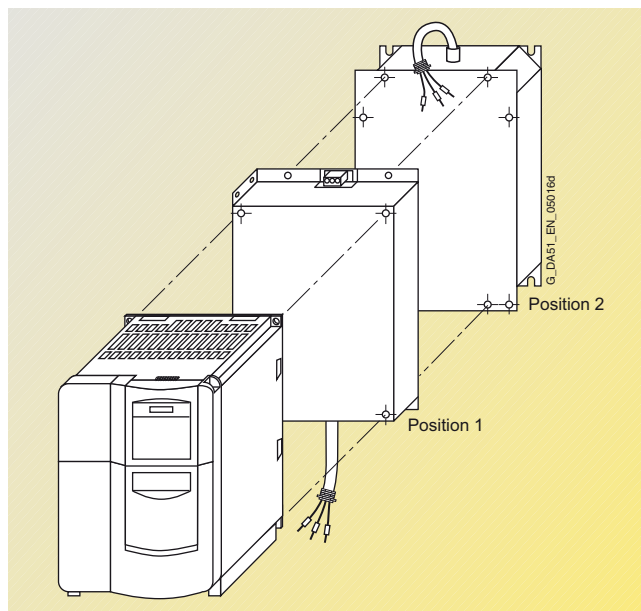
Note:

Operation up to 150 Hz output frequency only!

Frame size (FS)	Output choke Type	Max. permissible motor cable lengths (shielded/unshielded) for a mains voltage of			
		200 V to 240 V $\pm 10\%$	380 V to 400 V $\pm 10\%$	401 V to 480 V $\pm 10\%$	500 V to 600 V $\pm 10\%$
A	6SE6400-3TC00-4AD3	200 m/300 m	–	–	–
A	6SE6400-3TC00-4AD2	–	150 m/225 m	100 m/150 m	–
B	6SE6400-3TC01-0BD3	200 m/300 m	150 m/225 m	100 m/150 m	–
C	6SE6400-3TC03-2CD3	200 m/300 m	200 m/300 m	100 m/150 m	–
C	6SE6400-3TC01-8CE3	–	–	–	100 m/150 m
D to F	6SE6400-3TC.	200 m/300 m	200 m/300 m	200 m/300 m	200 m/300 m
FX	6SL3000-2BE32-1AA0	–	300 m/450 m	300 m/450 m	–
FX	6SL3000-2BE32-6AA0	–	300 m/450 m	300 m/450 m	–
GX	6SL3000-2BE33-2AA0	–	300 m/450 m	300 m/450 m	–
GX	6SL3000-2BE33-8AA0	–	300 m/450 m	300 m/450 m	–
GX	6SL3000-2BE35-0AA0	–	300 m/450 m	300 m/450 m	–

Design**General installation instructions**

- A maximum of two footprint components plus inverter are permissible.
- If an LC filter is used, it must, if possible, be mounted directly on the wall of the control cabinet due to weight reasons. If an LC filter of frame size C is used, therefore, only one footprint component is permissible. If a line choke and LC filter are used, the line choke must be located on the left of the inverter. Required distance between line choke and inverter: 75 mm.
- The EMC filter must be mounted directly below the frequency inverter if possible.
- If mounted on the side, the line-side components are to be mounted to the left of the frequency inverter whereas the output-side components are to be mounted to the right of the frequency inverter.
- If a braking resistor is used, it must, if possible, be mounted directly on the wall of the control cabinet due to reasons relating to temperature increases.



Example of installation with frequency inverter, EMC filter (position 1) and line choke (position 2)

Availability of the options as footprint components

	Frame size								
	A	B	C	D	E	F	G	FX	GX
Line commutating choke	✓	✓	✓	✓	✓				
EMC filter	✓	✓	✓						
LC filter	✓	✓	✓						
Output choke	✓	✓	✓						
Braking resistor	✓	✓							

Recommended combinations of inverters and options

Frequency inverter Frame size	Footprint Position 1	Position 2	Mounted on side	
			To the left of the inverter (for line-side components)	To the right of the inverter (for output-side components)
A and B	EMC filter	Line commutating choke	–	Output choke <u>and/or</u> Braking resistor
	EMC filter <u>or</u> Line commutating choke	Output choke <u>or</u> LC filter	–	Braking resistor
	EMC filter <u>or</u> Line commutating choke	Braking resistor	–	–
	EMC filter <u>or</u> Line commutating choke <u>or</u> Braking resistor	–	–	–
C	EMC filter	Line commutating choke	–	Output choke <u>and/or</u> Braking resistor
	EMC filter <u>or</u> Line commutating choke	Output choke	–	Braking resistor
	LC filter	–	EMC filter <u>and/or</u> Line commutating choke	Braking resistor
D and E	Line commutating choke	–	EMC filter	Output choke <u>or</u> LC filter <u>and/or</u> Braking resistor
F, G, FX and GX	–	–	EMC filter <u>and/or</u> Line commutating choke	Output choke <u>or</u> LC filter <u>and/or</u> Braking resistor

MICROMASTER 440

Options

Variant dependent options

Selection and ordering data

The options listed here (filters, chokes, brake resistors, gland plates, fuses and circuit-breakers) must be selected to match the respective inverter.

The inverter and the associated options have the same voltage ratings. Alternatively fuses and circuit-breakers can be provided. Both provide short




circuit protection of the inverter supply line and the inverter. A semiconductor protection of the inverter with the suggested 3NA... fuses and the

3RV.../3VL... circuit-breakers is not envisaged.

*) Must be used in combination with a line commutating choke.

Mains voltage	Output (CT)		Inverter without filter	Order No. of the options			
	kW	hp		EMC filter, Class A	EMC filter, Class B	Line commutating choke	
1 AC 200 V to 240 V	0.12	0.16	6SE6440-2UC11-2AA1	–	6SE6400-2FL01-0AB0 with low leakage currents	6SE6400-3CC00-4AB3	
	0.25	0.33	6SE6440-2UC12-5AA1	–		6SE6400-3CC01-0AB3	
	0.37	0.50	6SE6440-2UC13-7AA1	–			
	0.55	0.75	6SE6440-2UC15-5AA1	–			
	0.75	1.0	6SE6440-2UC17-5AA1	–	6SE6400-2FL02-6BB0 with low leakage currents	6SE6400-3CC02-6BB3	
	1.1	1.5	6SE6440-2UC21-1BA1	–			
	1.5	2.0	6SE6440-2UC21-5BA1	–			
	2.2	3.0	6SE6440-2UC22-2BA1	–			
	3.0	4.0	6SE6440-2UC23-0CA1	–			6SE6400-3CC03-5CB3
3 AC 200 V to 240 V	0.12	0.16	6SE6440-2UC11-2AA1	6SE6400-2FA00-6AD0	6SE6400-2FB00-6AD0	6SE6400-3CC00-3AC3	
	0.25	0.33	6SE6440-2UC12-5AA1			6SE6400-3CC00-5AC3	
	0.37	0.50	6SE6440-2UC13-7AA1				
	0.55	0.75	6SE6440-2UC15-5AA1				
	0.75	1.0	6SE6440-2UC17-5AA1	6SE6400-2FA01-4BC0	6SE6400-2FB01-4BC0	6SE6400-3CC00-8BC3 6SE6400-3CC01-4BD3	
	1.1	1.5	6SE6440-2UC21-1BA1				
	1.5	2.0	6SE6440-2UC21-5BA1				
	2.2	3.0	6SE6440-2UC22-2BA1				
	3.0	4.0	6SE6440-2UC23-0CA1				–
	4.0	5.0	6SE6440-2UC24-0CA1	–	–	6SE6400-3CC03-5CD3	
	5.5	7.5	6SE6440-2UC25-5CA1	–	–	6SE6400-3CC05-2DD0	
	7.5	10	6SE6440-2UC27-5DA1	–	–		
	11.0	15	6SE6440-2UC31-1DA1	–	–		
	15.0	20	6SE6440-2UC31-5DA1	–	–		
	18.5	25	6SE6440-2UC31-8EA1	–	–	6SE6400-3CC08-8EC0	
	22	30	6SE6440-2UC32-2EA1	–	–	6SE6400-3CC11-7FD0	
	30	40	6SE6440-2UC33-0FA1	–	–		
	37	50	6SE6440-2UC33-7FA1	–	–		
	45	60	6SE6440-2UC34-5FA1	–	–		
	3 AC 380 V to 480 V	0.37	0.50	6SE6440-2UD13-7AA1	6SE6400-2FA00-6AD0	6SE6400-2FB00-6AD0	6SE6400-3CC00-2AD3
		0.55	0.75	6SE6440-2UD15-5AA1			6SE6400-3CC00-4AD3
		0.75	1.0	6SE6440-2UD17-5AA1			
		1.1	1.5	6SE6440-2UD21-1AA1	6SE6400-3CC00-6AD3 6SE6400-3CC01-0BD3		
		1.5	2.0	6SE6440-2UD21-5AA1			
2.2		3.0	6SE6440-2UD22-2BA1	–		–	
3.0		4.0	6SE6440-2UD23-0BA1	–		–	
4.0		5.0	6SE6440-2UD24-0BA1	–	–	6SE6400-3CC01-4BD3	
5.5		7.5	6SE6440-2UD25-5CA1	–	–	6SE6400-3CC02-2CD3	
7.5		10	6SE6440-2UD27-5CA1	–	–	6SE6400-3CC03-5CD3 6SE6400-3CC04-4DD0	
11.0		15	6SE6440-2UD31-1CA1	–	–		
15.0		20	6SE6440-2UD31-5DA1	–	EMC filter, Class B, available from Schaffner		
18.5		25	6SE6440-2UD31-8DA1	–			
22		30	6SE6440-2UD32-2DA1	–		6SE6400-3CC05-2DD0	
30		40	6SE6440-2UD33-0EA1	–		6SE6400-3CC08-3ED0	
37		50	6SE6440-2UD33-7EA1	–	6SE6400-3CC11-2FD0		
45		60	6SE6440-2UD34-5FA1	–			
55		75	6SE6440-2UD35-5FA1	–			
75		100	6SE6440-2UD37-5FA1	–			
90		125	6SE6440-2UD38-8FA1	6SL3000-0BE32-5AA0 *)	–	6SL3000-0CE32-3AA0	
110		150	6SE6440-2UD41-1FA1	6SL3000-0BE34-4AA0 *)	–	6SL3000-0CE32-8AA0	
132		200	6SE6440-2UD41-3GA1	–	–	6SL3000-0CE33-3AA0	
160		250	6SE6440-2UD41-6GA1	–	–	6SL3000-0CE35-1AA0	
200		300	6SE6440-2UD42-0GA1	6SL3000-0BE36-0AA0 *)	–		
3 AC 500 V to 600 V	0.75	1.0	6SE6440-2UE17-5CA1	–	–	6SE6400-3CC00-4CE3	
	1.5	2.0	6SE6440-2UE21-5CA1	–	–	6SE6400-3CC00-8CE3	
	2.2	3.0	6SE6440-2UE22-2CA1	–	–		
	4.0	5.0	6SE6440-2UE24-0CA1	–	–		
	5.5	7.5	6SE6440-2UE25-5CA1	–	–	6SE6400-3CC02-4CE3	
	7.5	10	6SE6440-2UE27-5CA1	–	–	6SE6400-3CC04-4DD0	
	11.0	15	6SE6440-2UE31-1CA1	–	–		
	15.0	20	6SE6440-2UE31-5DA1	–	–		
	18.5	25	6SE6440-2UE31-8DA1	–	–		
	22	30	6SE6440-2UE32-2DA1	–	–	6SE6400-3CC08-3ED0	
	30	40	6SE6440-2UE33-0EA1	–	–		
	37	50	6SE6440-2UE33-7EA1	–	–		
	45	60	6SE6440-2UE34-5FA1	–	–	6SE6400-3CC11-2FD0	
	55	75	6SE6440-2UE35-5FA1	–	–		
	75	100	6SE6440-2UE37-5FA1	–	–		

Selection and ordering data (continued)

All options are certified to , except fuses.
The 3NE1 fuses are -listed (equivalent to ).

The fuses of type 3NA3 as well as circuit-breakers of type 3RV/3VL are recommended for Europe.

Additional information on the listed fuses and circuit-breakers can be found in Catalogs LV 10 and IC 10.

Mains voltage	Output (CT)		Inverter without filter	Order No. of the options LC/sinusoidal filter	Output choke	Brake resistors
	kW	hp				
1 AC 200 V to 240 V	0.12	0.16	6SE6440-2UC11-2AA1	–	6SE6400-3TC00-4AD3	6SE6400-4BC05-0AA0
	0.25	0.33	6SE6440-2UC12-5AA1	–		
	0.37	0.50	6SE6440-2UC13-7AA1	–		
	0.55	0.75	6SE6440-2UC15-5AA1	–		
	0.75	1.0	6SE6440-2UC17-5AA1	–		
	1.1	1.5	6SE6440-2UC21-1BA1	–	6SE6400-3TC01-0BD3	6SE6400-4BC11-2BA0
	1.5	2.0	6SE6440-2UC21-5BA1	–		
	2.2	3.0	6SE6440-2UC22-2BA1	–		
	3.0	4.0	6SE6440-2UC23-0CA1	–	6SE6400-3TC03-2CD3	6SE6400-4BC12-5CA0
					6SE6400-3TC00-4AD3	6SE6400-4BC05-0AA0
3 AC 200 V to 240 V	0.12	0.16	6SE6440-2UC11-2AA1	–		
	0.25	0.33	6SE6440-2UC12-5AA1	–		
	0.37	0.50	6SE6440-2UC13-7AA1	–		
	0.55	0.75	6SE6440-2UC15-5AA1	–		
	0.75	1.0	6SE6440-2UC17-5AA1	–		
	1.1	1.5	6SE6440-2UC21-1BA1	–	6SE6400-3TC01-0BD3	6SE6400-4BC11-2BA0
	1.5	2.0	6SE6440-2UC21-5BA1	–		
	2.2	3.0	6SE6440-2UC22-2BA1	–		
	3.0	4.0	6SE6440-2UC23-0CA1	–	6SE6400-3TC03-2CD3	6SE6400-4BC12-5CA0
	4.0	5.0	6SE6440-2UC24-0CA1	–		6SE6400-4BC13-0CA0
	5.5	7.5	6SE6440-2UC25-5CA1	–		
	7.5	10	6SE6440-2UC27-5DA1	–	6SE6400-3TC05-4DD0	6SE6400-4BC18-0DA0
	11.0	15	6SE6440-2UC31-1DA1	–		
	15.0	20	6SE6440-2UC31-5DA1	–		
	18.5	25	6SE6440-2UC31-8EA1	–	6SE6400-3TC08-0ED0	6SE6400-4BC21-2EA0
	22	30	6SE6440-2UC32-2EA1	–		
	30	40	6SE6440-2UC33-0FA1	–	6SE6400-3TC15-4FD0	6SE6400-4BC22-5FA0
	37	50	6SE6440-2UC33-7FA1	–		
	45	60	6SE6440-2UC34-5FA1	–		
3 AC 380 V to 480 V	0.37	0.50	6SE6440-2UD13-7AA1	6SE6400-3TD00-4AD0	6SE6400-3TC00-4AD2	6SE6400-4BD11-0AA0
	0.55	0.75	6SE6440-2UD15-5AA1			
	0.75	1.0	6SE6440-2UD17-5AA1			
	1.1	1.5	6SE6440-2UD21-1AA1			
	1.5	2.0	6SE6440-2UD21-5AA1			
	2.2	3.0	6SE6440-2UD22-2BA1	6SE6400-3TD01-0BD0	6SE6400-3TC01-0BD3	6SE6400-4BD12-0BA0
	3.0	4.0	6SE6440-2UD23-0BA1			
	4.0	5.0	6SE6440-2UD24-0BA1			
	5.5	7.5	6SE6440-2UD25-5CA1	6SE6400-3TD03-2CD0	6SE6400-3TC03-2CD3	6SE6400-4BD16-5CA0
	7.5	10	6SE6440-2UD27-5CA1			
	11.0	15	6SE6440-2UD31-1CA1			
	15.0	20	6SE6440-2UD31-5DA1	6SE6400-3TD03-7DD0	6SE6400-3TC05-4DD0	6SE6400-4BD21-2DA0
	18.5	25	6SE6440-2UD31-8DA1	6SE6400-3TD04-8DD0	6SE6400-3TC03-8DD0	
	22	30	6SE6440-2UD32-2DA1	6SE6400-3TD06-1DD0	6SE6400-3TC05-4DD0	
	30	40	6SE6440-2UD33-0EA1	6SE6400-3TD07-2ED0	6SE6400-3TC08-0ED0	6SE6400-4BD22-2EA0
	37	50	6SE6440-2UD33-7EA1	6SE6400-3TD11-5FD0	6SE6400-3TC07-5ED0	
	45	60	6SE6440-2UD34-5FA1		6SE6400-3TC14-5FD0	6SE6400-4BD24-0FA0
	55	75	6SE6440-2UD35-5FA1	6SE6400-3TD15-0FD0	6SE6400-3TC15-4FD0	
	75	100	6SE6440-2UD37-5FA1	6SE6400-3TD18-0FD0	6SE6400-3TC14-5FD0	
	90	125	6SE6440-2UD38-8FA1	6SL3000-2CE32-3AA0	6SL3000-2BE32-1AA0	–
	110	150	6SE6440-2UD41-1FA1		6SL3000-2BE32-6AA0	–
	132	200	6SE6440-2UD41-3GA1	6SL3000-2CE32-8AA0	6SL3000-2BE33-2AA0	–
	160	250	6SE6440-2UD41-6GA1	6SL3000-2CE33-3AA0	6SL3000-2BE33-8AA0	–
	200	300	6SE6440-2UD42-0GA1	6SL3000-2CE34-1AA0	6SL3000-2BE35-0AA0	–
3 AC 500 V to 600 V	0.75	1.0	6SE6440-2UE17-5CA1	6SE6400-3TD01-0CE0	6SE6400-3TC01-8CE3	6SE6400-4BE14-5CA0
	1.5	2.0	6SE6440-2UE21-5CA1			
	2.2	3.0	6SE6440-2UE22-2CA1			
	4.0	5.0	6SE6440-2UE24-0CA1			
	5.5	7.5	6SE6440-2UE25-5CA1	6SE6400-3TD02-3CE0		
	7.5	10	6SE6440-2UE27-5CA1			6SE6400-4BE16-5CA0
	11.0	15	6SE6440-2UE31-1CA1			
	15.0	20	6SE6440-2UE31-5DA1	6SE6400-3TD02-3DE0	6SE6400-3TC03-2DE0	6SE6400-4BE21-3DA0
	18.5	25	6SE6440-2UE31-8DA1	6SE6400-3TD03-2DE0		
	22	30	6SE6440-2UE32-2DA1	6SE6400-3TD03-7DE0		
	30	40	6SE6440-2UE33-0EA1	6SE6400-3TD04-8EE0	6SE6400-3TC06-2FE0	6SE6400-4BE21-8EA0
	37	50	6SE6440-2UE33-7EA1	6SE6400-3TD06-1EE0		
	45	60	6SE6440-2UE34-5FA1	6SE6400-3TD07-1FE0		6SE6400-4BE24-2FA0
	55	75	6SE6440-2UE35-5FA1	6SE6400-3TD10-0FE0	6SE6400-3TC08-8FE0	
	75	100	6SE6440-2UE37-5FA1	6SE6400-3TD11-5FE0		

MICROMASTER 440

Options Variant dependent options

Selection and ordering data (continued)

● Use in America requires Ⓢ-listed fuses Class J.

Mains voltage	Output (CT)		Inverter without filter	Order No. of options Gland plate	Fuses (see LV 10)		Circuit-breaker (see Cat. IC 10/LV 10)
	kW	hp			3NA3	3NE1 (Ⓢ)	
1 AC 200 V to 240 V	0.12	0.16	6SE6440-2UC11-2AA1	6SE6400-0GP00-0AA0	3NA3803	●	3RV2011-1EA10
	0.25	0.33	6SE6440-2UC12-5AA1				3RV2011-1HA10
	0.37	0.50	6SE6440-2UC13-7AA1				3RV2011-1JA10
	0.55	0.75	6SE6440-2UC15-5AA1				3RV2011-1KA10
	0.75	1.0	6SE6440-2UC17-5AA1	6SE6400-0GP00-0BA0	3NA3805		3RV2021-4AA10
	1.1	1.5	6SE6440-2UC21-1BA1				3RV2021-4DA10
	1.5	2.0	6SE6440-2UC21-5BA1				3RV1031-4EA10
	2.2	3.0	6SE6440-2UC22-2BA1				3RV1031-4FA10
	3.0	4.0	6SE6440-2UC23-0CA1	6SE6400-0GP00-0CA0	3NA3812		3RV1041-4JA10
3 AC 200 V to 240 V	0.12	0.16	6SE6440-2UC11-2AA1	6SE6400-0GP00-0AA0	3NA3803	●	3RV2011-1BA10
	0.25	0.33	6SE6440-2UC12-5AA1				3RV2011-1DA10
	0.37	0.50	6SE6440-2UC13-7AA1				3RV2011-1FA10
	0.55	0.75	6SE6440-2UC15-5AA1				3RV2011-1GA10
	0.75	1.0	6SE6440-2UC17-5AA1	6SE6400-0GP00-0BA0	3NA3805		3RV2011-1HA10
	1.1	1.5	6SE6440-2UC21-1BA1				3RV2011-1KA10
	1.5	2.0	6SE6440-2UC21-5BA1				3RV2021-4AA10
	2.2	3.0	6SE6440-2UC22-2BA1				3RV2021-4CA10
	3.0	4.0	6SE6440-2UC23-0CA1	6SE6400-0GP00-0CA0	3NA3810		3RV2021-4EA10
	4.0	5.0	6SE6440-2UC24-0CA1				3RV1031-4FA10
	5.5	7.5	6SE6440-2UC25-5CA1				3RV1031-4HA10
	7.5	10	6SE6440-2UC27-5DA1				3RV1042-4JA10
	11.0	15	6SE6440-2UC31-1DA1	Integrated as standard for shield connection of the control cable and the power cable.	3NA3820	3NE1817-0	3RV1042-4LA10
	15.0	20	6SE6440-2UC31-5DA1				3VL1712-.DD33-....
	18.5	25	6SE6440-2UC31-8EA1				
	22	30	6SE6440-2UC32-2EA1				
	30	40	6SE6440-2UC33-0FA1	Integrated as standard for shield connection of the control cable. The shield of the power cable has to be connected externally (e.g. in the control cabinet).	3NA3830	3NE1021-0	3VL1716-.DD33-....
	37	50	6SE6440-2UC33-7FA1				3VL3725-.DC36-....
	45	60	6SE6440-2UC34-5FA1				3VL4731-.DC36-....
					3NA3832	3NE1022-0	
					3NA3140	3NE1225-0	
					3NA3142	3NE1225-0	
					3NA3144	3NE1227-0	
3 AC 380 V to 480 V	0.37	0.50	6SE6440-2UD13-7AA1	6SE6400-0GP00-0AA0	3NA3803	●	3RV2011-1CA10
	0.55	0.75	6SE6440-2UD15-5AA1				3RV2011-1DA10
	0.75	1.0	6SE6440-2UD17-5AA1				3RV2011-1FA10
	1.1	1.5	6SE6440-2UD21-1AA1				3RV2011-1GA10
	1.5	2.0	6SE6440-2UD21-5AA1	6SE6400-0GP00-0BA0	3NA3805		3RV2011-1JA10
	2.2	3.0	6SE6440-2UD22-2BA1				3RV2011-1KA10
	3.0	4.0	6SE6440-2UD23-0BA1				3RV2021-4AA10
	4.0	5.0	6SE6440-2UD24-0BA1				3RV2021-4BA10
	5.5	7.5	6SE6440-2UD25-5CA1	6SE6400-0GP00-0CA0	3NA3807		3RV1031-4EA10
	7.5	10	6SE6440-2UD27-5CA1				3RV1031-4FA10
	11.0	15	6SE6440-2UD31-1CA1				3RV1031-4HA10
	15.0	20	6SE6440-2UD31-5DA1				3RV1042-4KA10
	18.5	25	6SE6440-2UD31-8DA1	Integrated as standard for shield connection of the control cable and the power cable.	3NA3820	3NE1817-0	
	22	30	6SE6440-2UD32-2DA1				3RV1042-4MA10
	30	40	6SE6440-2UD33-0EA1				3VL1712-.DD33-....
	37	50	6SE6440-2UD33-7EA1				3VL1716-.DD33-....
	45	60	6SE6440-2UD34-5FA1	Integrated as standard for shield connection of the control cable. The shield of the power cable has to be connected externally (e.g. in the control cabinet).	3NA3830	3NE1224-0	3VL3720-.DC36-....
	55	75	6SE6440-2UD35-5FA1				3VL3725-.DC36-....
	75	100	6SE6440-2UD37-5FA1				
	90	125	6SE6440-2UD38-8FA1				3VL4731-.DC36-....
	110	150	6SE6440-2UD41-1FA1		–	3NE1230-0	
	132	200	6SE6440-2UD41-3GA1				
	160	250	6SE6440-2UD41-6GA1				
	200	300	6SE6440-2UD42-0GA1				
						3NE1332-0	
						3NE1333-0	3VL4740-.DC36-....
						3NE1435-0	3VL5750-.DC36-....
3 AC 500 V to 600 V	0.75	1.0	6SE6440-2UE17-5CA1	6SE6400-0GP00-0CA0	3NA3803-6	●	3RV2011-1EA10
	1.5	2.0	6SE6440-2UE21-5CA1				3RV2011-1GA10
	2.2	3.0	6SE6440-2UE22-2CA1				3RV2011-1JA10
	4.0	5.0	6SE6440-2UE24-0CA1				3RV2021-4AA10
	5.5	7.5	6SE6440-2UE25-5CA1		3NA3805-6		3RV2021-4BA10
	7.5	10	6SE6440-2UE27-5CA1				3RV2021-4DA10
	11.0	15	6SE6440-2UE31-1CA1				3RV2021-4FA10
	15.0	20	6SE6440-2UE31-5DA1				3RV1031-4HA10
	18.5	25	6SE6440-2UE31-8DA1	Integrated as standard for shield connection of the control cable and the power cable.	3NA3814-6	3NE1803-0	3RV1042-4JA10
	22	30	6SE6440-2UE32-2DA1				3RV1042-4KA10
	30	40	6SE6440-2UE33-0EA1				3RV1042-4MA10
	37	50	6SE6440-2UE33-7EA1				3VL1712-.DD33-....
	45	60	6SE6440-2UE34-5FA1	Integrated as standard for shield connection of the control cable. The shield of the power cable has to be connected externally (e.g. in the control cabinet).	3NA3132-6	3NE1022-0	3VL1716-.DD33-....
	55	75	6SE6440-2UE35-5FA1				3VL3720-.DC36-....
	75	100	6SE6440-2UE37-5FA1				3VL3725-.DC36-....

Selection and ordering data (continued)

Mains voltage	Output (CT)		Inverter with internal filter Class A	Order No. of options Additional EMC filter, Class B	Line commutating choke	LC filter
	kW	hp				
1 AC 200 V to 240 V	0.12	0.16	6SE6440-2AB11-2AA1	6SE6400-2FS01-0AB0	6SE6400-3CC00-4AB3	–
	0.25	0.33	6SE6440-2AB12-5AA1		–	–
	0.37	0.50	6SE6440-2AB13-7AA1		6SE6400-3CC01-0AB3	–
	0.55	0.75	6SE6440-2AB15-5AA1		–	–
	0.75	1.0	6SE6440-2AB17-5AA1		–	–
	1.1	1.5	6SE6440-2AB21-1BA1	6SE6400-2FS02-6BB0	6SE6400-3CC02-6BB3	–
	1.5	2.0	6SE6440-2AB21-5BA1		–	–
	2.2	3.0	6SE6440-2AB22-2BA1		–	–
	3.0	4.0	6SE6440-2AB23-0CA1		6SE6400-3CC03-5CB3	–
	3.0	4.0	6SE6440-2AC23-0CA1	6SE6400-2FS03-8CD0	6SE6400-3CC01-7CC3	–
3 AC 200 V to 240 V	4.0	5.0	6SE6440-2AC24-0CA1		6SE6400-3CC03-5CD3	–
	5.5	7.5	6SE6440-2AC25-5CA1		–	–
3 AC 380 V to 480 V	2.2	3.0	6SE6440-2AD22-2BA1	6SE6400-2FS01-6BD0	6SE6400-3CC01-0BD3	6SE6400-3TD01-0BD0
	3.0	4.0	6SE6440-2AD23-0BA1		–	–
	4.0	5.0	6SE6440-2AD24-0BA1		6SE6400-3CC01-4BD3	–
	5.5	7.5	6SE6440-2AD25-5CA1		6SE6400-3CC02-2CD3	6SE6400-3TD03-2CD0
	7.5	10	6SE6440-2AD27-5CA1		–	–
	11.0	15	6SE6440-2AD31-1CA1	6SE6400-2FS03-8CD0	6SE6400-3CC03-5CD3	–
	15.0	20	6SE6440-2AD31-5DA1		6SE6400-3CC04-4DD0	6SE6400-3TD03-7DD0
	18.5	25	6SE6440-2AD31-8DA1		–	6SE6400-3TD04-8DD0
	22	30	6SE6440-2AD32-2DA1		6SE6400-3CC05-2DD0	6SE6400-3TD06-1DD0
	30	40	6SE6440-2AD33-0EA1		6SE6400-3CC08-3ED0	6SE6400-3TD07-2ED0
	37	50	6SE6440-2AD33-7EA1		–	6SE6400-3TD11-5FD0
	45	60	6SE6440-2AD34-5FA1		6SE6400-3CC11-2FD0	–
	55	75	6SE6440-2AD35-5FA1		–	6SE6400-3TD15-0FD0
	75	100	6SE6440-2AD37-5FA1		6SE6400-3CC11-7FD0	6SE6400-3TD18-0FD0
Mains voltage	Output (CT)		Inverter with internal filter Class A	Order No. of options Output choke	Brake resistors	Gland plate
	kW	hp				
1 AC 200 V to 240 V	0.12	0.16	6SE6440-2AB11-2AA1	6SE6400-3TC00-4AD3	6SE6400-4BC05-0AA0	6SE6400-0GP00-0AA0
	0.25	0.33	6SE6440-2AB12-5AA1		–	–
	0.37	0.50	6SE6440-2AB13-7AA1		–	–
	0.55	0.75	6SE6440-2AB15-5AA1		–	–
	0.75	1.0	6SE6440-2AB17-5AA1		–	–
	1.1	1.5	6SE6440-2AB21-1BA1	6SE6400-3TC01-0BD3	6SE6400-4BC11-2BA0	6SE6400-0GP00-0BA0
	1.5	2.0	6SE6440-2AB21-5BA1		–	–
	2.2	3.0	6SE6440-2AB22-2BA1		–	–
	3.0	4.0	6SE6440-2AB23-0CA1		6SE6400-4BC12-5CA0	6SE6400-0GP00-0CA0
	3.0	4.0	6SE6440-2AC23-0CA1	6SE6400-3TC03-2CD3	6SE6400-4BC12-5CA0	6SE6400-0GP00-0CA0
3 AC 200 V to 240 V	4.0	5.0	6SE6440-2AC24-0CA1		6SE6400-4BC13-0CA0	–
	5.5	7.5	6SE6440-2AC25-5CA1		–	–
3 AC 380 V to 480 V	2.2	3.0	6SE6440-2AD22-2BA1	6SE6400-3TC01-0BD3	6SE6400-4BD12-0BA0	6SE6400-0GP00-0BA0
	3.0	4.0	6SE6440-2AD23-0BA1		–	–
	4.0	5.0	6SE6440-2AD24-0BA1		–	–
	5.5	7.5	6SE6440-2AD25-5CA1		6SE6400-4BD16-5CA0	6SE6400-0GP00-0CA0
	7.5	10	6SE6440-2AD27-5CA1		–	–
	11.0	15	6SE6440-2AD31-1CA1	6SE6400-3TC03-2CD3	–	–
	15.0	20	6SE6440-2AD31-5DA1		6SE6400-4BD21-2DA0	Integrated as standard for shield connection of the control cable and the power cable.
	18.5	25	6SE6440-2AD31-8DA1		6SE6400-3TC03-8DD0	
	22	30	6SE6440-2AD32-2DA1		6SE6400-3TC05-4DD0	
	30	40	6SE6440-2AD33-0EA1		6SE6400-3TC08-0ED0	
	37	50	6SE6440-2AD33-7EA1		6SE6400-3TC07-5ED0	
	45	60	6SE6440-2AD34-5FA1		6SE6400-3TC14-5FD0	
	55	75	6SE6440-2AD35-5FA1		6SE6400-3TC15-4FD0	
	75	100	6SE6440-2AD37-5FA1		6SE6400-3TC14-5FD0	

MICROMASTER 440

Options Variant dependent options

Selection and ordering data (continued)

Mains voltage	Output (CT)		Inverter with internal filter Class A	Order No. of the options Fuses (see Catalog LV 10)		Circuit-breaker (see Cat. IC 10/LV 10)
	kW	hp		3NA3	3NE1 (9A)	
1 AC 200 V to 240 V	0.12	0.16	6SE6440-2AB11-2AA1	3NA3803	●	3RV2011-1EA10
	0.25	0.33	6SE6440-2AB12-5AA1			3RV2011-1HA10
	0.37	0.50	6SE6440-2AB13-7AA1			3RV2011-1JA10
	0.55	0.75	6SE6440-2AB15-5AA1	3NA3805		3RV2011-1KA10
	0.75	1.0	6SE6440-2AB17-5AA1			3RV2021-4AA10
	1.1	1.5	6SE6440-2AB21-1BA1	3NA3807		3RV2021-4DA10
	1.5	2.0	6SE6440-2AB21-5BA1			3RV1031-4EA10
	2.2	3.0	6SE6440-2AB22-2BA1	3NA3812		3RV1031-4FA10
3 AC 200 V to 240 V	3.0	4.0	6SE6440-2AB23-0CA1	3NA3817		3RV1041-4JA10
	3.0	4.0	6SE6440-2AC23-0CA1	3NA3810	●	3RV1031-4EA10
	4.0	5.0	6SE6440-2AC24-0CA1	3NA3812		3RV1031-4FA10
	5.5	7.5	6SE6440-2AC25-5CA1	3NA3814		3RV1031-4HA10
3 AC 380 V to 480 V	2.2	3.0	6SE6440-2AD22-2BA1	3NA3805	●	3RV2011-1KA10
	3.0	4.0	6SE6440-2AD23-0BA1			3RV2021-4AA10
	4.0	5.0	6SE6440-2AD24-0BA1	3NA3807		3RV2021-4BA10
	5.5	7.5	6SE6440-2AD25-5CA1			3RV1031-4EA10
	7.5	10	6SE6440-2AD27-5CA1	3NA3812		3RV1031-4FA10
	11.0	15	6SE6440-2AD31-1CA1	3NA3814		3RV1031-4HA10
	15.0	20	6SE6440-2AD31-5DA1	3NA3820	3NE1817-0	3RV1042-4KA10
	18.5	25	6SE6440-2AD31-8DA1	3NA3822	3NE1818-0	
	22	30	6SE6440-2AD32-2DA1	3NA3824	3NE1820-0	3RV1042-4MA10
	30	40	6SE6440-2AD33-0EA1	3NA3830	3NE1021-0	3VL1712-.DD33-....
	37	50	6SE6440-2AD33-7EA1	3NA3832	3NE1022-0	3VL1716-.DD33-....
	45	60	6SE6440-2AD34-5FA1	3NA3836	3NE1224-0	3VL3720-.DC36-....
	55	75	6SE6440-2AD35-5FA1	3NA3140	3NE1225-0	3VL3725-.DC36-....
	75	100	6SE6440-2AD37-5FA1	3NA3144	3NE1227-0	

● Use in America requires
Ⓜ-listed fuses Class J.

Overview**Basic Operator Panel (BOP)**

With the BOP, individual parameter settings can be made. Values and units are shown on a 5-digit display.



Basic Operator Panel (BOP)

A BOP can be used for several inverters. It can be directly mounted on the inverter or in a control cabinet door using a mounting kit.

Advanced Operator Panel (AOP)

The AOP enables MICROMASTER 440 parameter kits to be easily read and modified. In contrast to the BOP, the value and meaning of the parameters can be directly displayed as plain text in several languages by fast scrolling of the address.



Advanced Operator Panel (AOP)

The AOP is directly plugged into the inverter, or communicates with the latter through a door mounting kit. Together with the "AOP door mounting kit for multiple inverters", the AOP permits bus communication with up to 30 inverters at a transmission rate of 38 kbaud. (RS485, USS).

For servicing purposes, the AOP furthermore supports the download and upload of complete parameter kits.

Asian Advanced Operator Panel (AAOP)

The AAOP is the Chinese version of the AOP operator panel. It has an enhanced display and supports the operating languages of Chinese (simplified) and English.



Asian Advanced Operator Panel (AAOP)

Cyrillic Advanced Operator Panel (CAOP)

The CAOP is the Cyrillic version of the AOP Advanced Operator Panel. It supports the Cyrillic, German and English operator languages.

PROFIBUS module

For a complete PROFIBUS connection with up to ≤ 12 Mbaud. Remote control of the inverter is possible with the PROFIBUS module. Remote control and operation at the inverter can be combined using an operator panel plugged onto the PROFIBUS module. The PROFIBUS module can be supplied by an external 24 V DC power supply and is thus also active when the inverter is disconnected from the power supply.

Connection by means of a 9-pin Sub-D connector (available as an option).

DeviceNet module

For networking the inverters to the DeviceNet fieldbus system widely used on the American market. A maximum transmission rate of 500 kbaud is possible. Remote control of the inverter is possible with the DeviceNet module. Remote control and operation at the inverter can be combined using an operator panel plugged onto the DeviceNet module.

The connection to the DeviceNet bus system is made using a 5-pin connector with terminal strip.

CANopen module

Using the CANopen communications module, an inverter can be linked to the CANopen fieldbus system and remote control is then possible.

Remote control and operation at the inverter can be combined using an operator panel plugged onto the CANopen module.

The module is connected to the bus system through a 9-pin Sub-D connector.

Pulse encoder evaluation module

The pulse encoder evaluation module permits direct connection of the most widely encountered digital pulse encoders to the inverter.

They offer the following functions:

- Zero speed at full load torque
- Extremely accurate speed control
- Increased dynamic response of speed and torque control.

This module can be used with HTL and TTL pulse encoders (High voltage Transistor Logic, 24 V and Transistor Logic, 5 V).

MICROMASTER 440

Options

Variant independent options

Overview (continued)

Connection kit for PC to inverter

For controlling an inverter directly from a PC if the appropriate software has been installed (e.g. STARTER). Isolated RS-232 adapter module for reliable point-to-point connection to a PC. Includes a Sub-D connector and an RS-232 standard cable (3 m).

Connection kit for PC to AOP

For connecting a PC to an AOP or AAOP. Offline programming of inverters and archiving of parameter kits possible. Includes a desktop attachment kit for an AOP or AAOP, an RS-232 standard cable (3 m) with Sub-D connectors and a universal power supply unit.

Operator panel door mounting kit for single inverter

For mounting an operator panel in a control cabinet door. Degree of protection IP56. Contains a cable adapter module with screwless terminals for use with user's own RS-232 cables ¹⁾.

AOP door mounting kit for multiple inverters (USS)

For mounting an AOP or AAOP in a control cabinet door. Degree of protection IP56. The AOP or AAOP can communicate with several inverters by means of the RS-485 USS protocol. The 4-pin connecting cable from the AOP or AAOP to the RS-485 terminals of the inverter and to the 24 V user terminal strip is not included ²⁾.

Start-up tools

- **STARTER**
Starter is graphic start-up software for guided start-up for MICROMASTER 410/420/430/440 frequency inverters under Windows 2000/XP Professional. Parameter lists can be read out, altered, stored, entered and printed.
- **DriveMonitor**
is a start-up software for list-oriented programming of frequency inverters. This program executes under Windows 98/NT/2000/ME/XP Professional.

Both programs are included on the Docu DVD which is provided with every inverter.

Selection and ordering data

The options listed here are suitable for all MICROMASTER 440 inverters.

Options	Order No.	
Basic Operator Panel (BOP)	6SE6400-0BP00-0AA0	
Advanced Operator Panel (AOP)	6SE6400-0AP00-0AA1	
Asian Advanced Operator Panel (AAOP)	6SE6400-0AP00-0AB0	
Cyrillic Advanced Operator Panel (CAOP)	6SE6400-0AP00-0CA0	
PROFIBUS module	6SE6400-1PB00-0AA0	
DeviceNet module	6SE6400-1DN00-0AA0	
CANopen module	6SE6400-1CB00-0AA0	
Pulse encoder evaluation module	6SE6400-0EN00-0AA0	
RS485/PROFIBUS bus connector	6GK1500-0FC00	
Connection kit for PC to inverter	6SE6400-1PC00-0AA0	
Connection kit for PC to AOP	6SE6400-0PA00-0AA0	
Operator panel door mounting kit for single inverter	6SE6400-0PM00-0AA0	
AOP door mounting kit for multiple inverters (USS)	6SE6400-0MD00-0AA0	
Start-up tool STARTER on DVD	6SL3072-0AA00-0AG0	Available on the Internet at: http://support.automation.siemens.com/WW/view/en/10804985/133100

1) A shielded cable of type Belden 8132 (28 AWG) is recommended. The maximum cable length is 5 m for RS-232.

2) A shielded cable of type Belden 8132 (28 AWG) is recommended. The maximum cable length is 10 m for RS-485.

Technical data



		PROFIBUS module 6SE6400-1PB00-0AA0	DeviceNet module 6SE6400-1DN00-0AA0
			
Size (height x width x depth)		161 mm x 73 mm x 46 mm	
Degree of protection		IP20	
Degree of pollution		2 to IEC 60664-1 (DIN VDE 0110/T1), no condensation permitted during operation	
Strain resistance	• Stationary	to IEC 60068-2-6 (if module is installed correctly) 0.15 mm in the frequency range of 10 Hz to 58 Hz 19.6 m/s² in the frequency range of 58 Hz to 500 Hz 3.5 mm in the frequency range of 5 Hz to 9 Hz 9.8 m/s² in the frequency range of 9 Hz to 500 Hz	
	• Transport		
Climatic category (during operation)		3K3 to IEC 60721-3-3	
Cooling method		Natural air cooling	
Permissible ambient or cooling agent temperature		–10 °C to +50 °C (+14 °F to +122 °F) –25 °C to +70 °C (–13 °F to +158 °F)	
• Operation			
• Storage and transport			
Relative humidity (permissible humidity rating)		≤ 85 % (non-condensing) ≤ 95 %	
• Operation			
• Storage and transport			
Electromagnetic compatibility	Emission	to EN 55011 (1991) Class A to IEC 60801-3 and EN 61000-4-3	
	Interference		
Power supply		6.5 V ± 5 %, max. 300 mA, internal from inverter or 24 V ± 10 %, max. 350 mA, external	6.5 V ± 5 %, max. 300 mA internal from inverter or 24 V, max. 60 mA from DeviceNet-Bus
Output voltage		5 V ± 10 %, max. 100 mA, galvanically isolated supply • for terminating the serial interface bus or • for supplying the OLP (Optical Link Plug)	–
Data transmission rate		max. 12 Mbaud	125, 250 and 500 Kbaud

MICROMASTER 440

Options

Variant independent options

Technical data (continued)

		CANopen module 6SE6400-1CB00-0AA0	Pulse encoder evaluation module 6SE6400-0EN00-0AA0
			
Size (height x width x depth)		161 mm x 73 mm x 46 mm	161 mm x 73 mm x 42 mm
Degree of protection		IP20	
Degree of pollution		2 to IEC 60 664-1 (DIN VDE 0110/T1), no condensation permitted during operation	
Strain resistance	• Stationary	to IEC 60 068-2-6 (if module is installed correctly) 0.15 mm in the frequency range of 10 Hz to 58 Hz 19.6 m/s ² in the frequency range of 58 Hz to 500 Hz 3.5 mm in the frequency range of 5 Hz to 9 Hz 9.8 m/s ² in the frequency range of 9 Hz to 500 Hz	
	• Transport		
Climatic category (during operation)		3K3 to IEC 60 721-3-3	
Cooling method		Natural air cooling	
Permissible ambient or cooling agent temperature		–10 °C to +50 °C (+14 °F to +122 °F) –40 °C to +70 °C (–40 °F to +158 °F) –25 °C to +70 °C (–13 °F to +158 °F)	
• Operation		–10 °C to +50 °C (+14 °F to +122 °F)	
• Storage		–20 °C to +70 °C (–14 °F to +158 °F)	
• Transportation		–20 °C to +70 °C (–14 °F to +158 °F)	
Electromagnetic compatibility	Emission	to EN 55 011 (1991) Class A to IEC 60 801-3 and EN 61 000-4-3	
	Interference		
Relative humidity (permissible humidity rating)		≤ 85 % (non-condensing) ≤ 95 %	
• Operation		≤ 85 % (non-condensing)	
• Storage and transport		≤ 95 %	
Power supply		The CAN bus is supplied from the inverter power supply	5 V ± 5 %, 330 mA or 18 V non-regulated, 140 mA, short-circuit proof
Data transmission rate		10, 20, 50, 125, 250, 500, 800 kbaud and 1 Mbaud	–
Pulse frequency		–	max. 300 kHz

Selection and ordering data

Type of documentation	Language	Order No.
Docu pack , supplied with each inverter, containing DVD ¹⁾ and Getting Started Guide ²⁾ (paper version)	Multilanguage	6SE6400-5AD00-1AP1
Operating instructions (paper version)	German, English, French, Italian, Spanish Available as pdf file on the Internet at http://support.automation.siemens.com/WW/view/en/10804926/133300	
Parameter list (paper version)	German, English, French, Italian, Spanish Available as pdf file on the Internet at http://support.automation.siemens.com/WW/view/en/10804926/133300	

1) The DVD contains operating instructions, parameter list, commissioning tools STARTER and DriveMonitor, multilanguage.

Available on the Internet:
DriveMonitor at
<http://support.automation.siemens.com/WW/view/en/10804984/133100>

STARTER at
<http://support.automation.siemens.com/WW/view/en/10804985/133100>

2) Available on the Internet at
<http://support.automation.siemens.com/WW/view/en/10804926/133300>

MICROMASTER 440

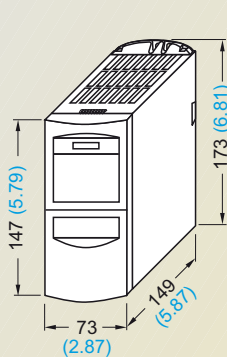
Dimension drawings

MICROMASTER 440 inverter

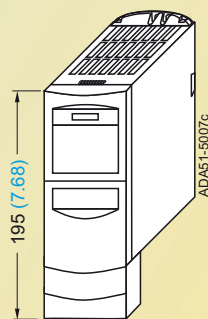
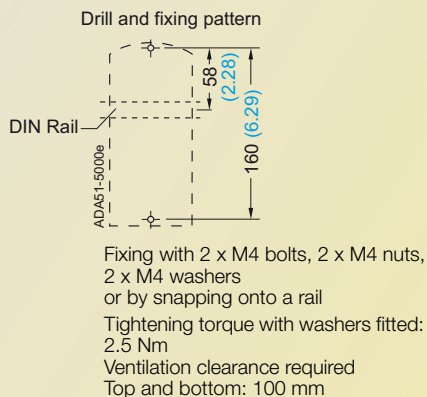
Frame size	1/3 AC 200 V to 240 V	3 AC 380 V to 480 V	3 AC 500 V to 600 V
A	0.12 kW to 0.75 kW	0.37 kW to 1.5 kW	–
B	1.1 kW to 2.2 kW	2.2 kW to 4 kW	–
C	3 kW to 5.5 kW	5.5 kW to 11 kW	0.75 kW to 11 kW

The specified outputs are valid for CT mode.

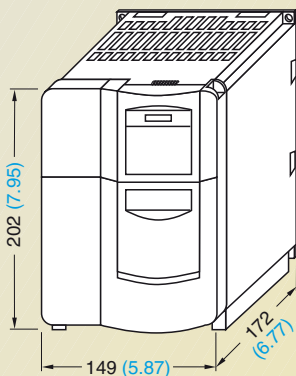
Note:
The inverters must not be mounted horizontally. But the inverters can be mounted without lateral spacing.



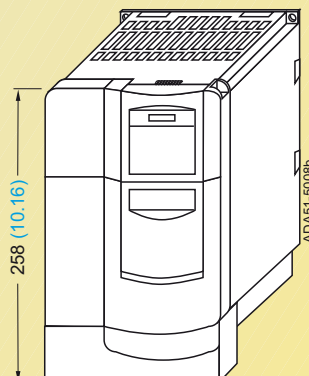
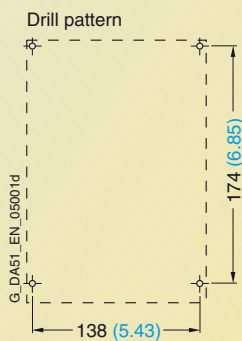
Inverter frame size **A**



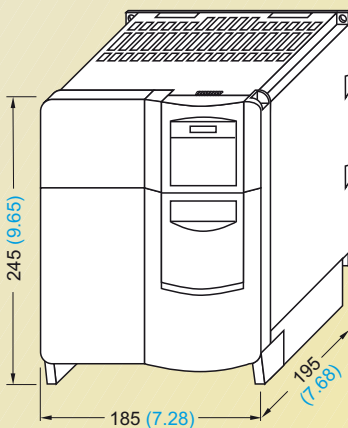
Inverter frame size **A** with **gland plate**



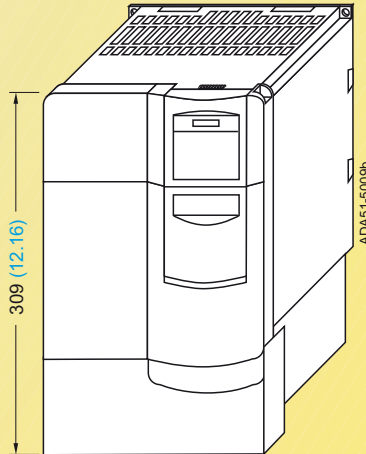
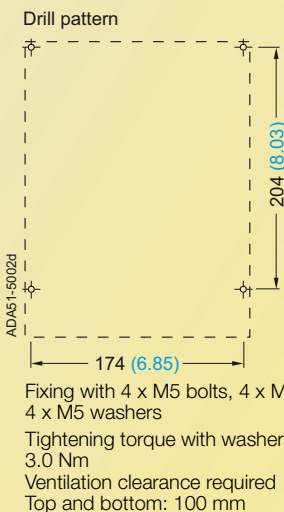
Inverter frame size **B**



Inverter frame size **B** with **gland plate**



Inverter frame size **C**



Inverter frame size **C** with **gland plate**

With the communications module, the mounting depth increases by 23 mm (0.91 inches). If a pulse encoder evaluation module is mounted in addition, the installation depth increases by another 23 mm (0.91 inches).

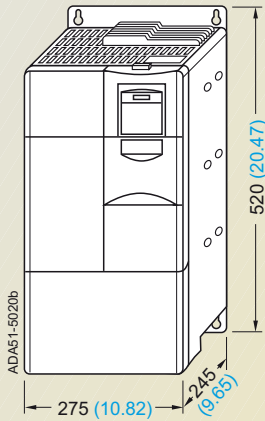
All dimensions in mm (values in brackets are in inches)

MICROMASTER 440 inverter (continued)

Frame size	3 AC 200 V to 240 V	3 AC 380 V to 480 V	3 AC 500 V to 600 V
D	7.5 kW to 15 kW	15 kW to 22 kW	15 kW to 22 kW
E	18.5 kW to 22 kW	30 kW to 37 kW	30 kW to 37 kW
F	30 kW to 45 kW	45 kW to 75 kW	45 kW to 75 kW

The specified outputs are valid for CT mode.

Note:
The inverters must not be mounted horizontally. But the inverters can be mounted without lateral spacing.

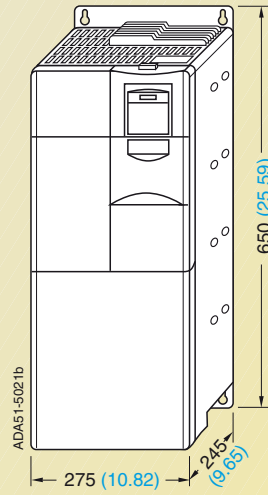


Inverter frame size D

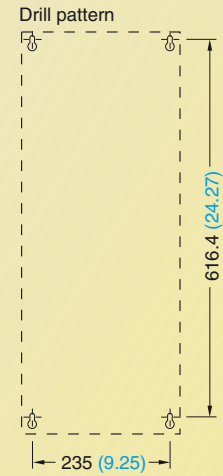


Fixing with
4 x M8 bolts, 4 x M8 nuts,
4 x M8 washers

Tightening torque with washers
fitted: 13 Nm
Ventilation clearance required
Top and bottom: 300 mm

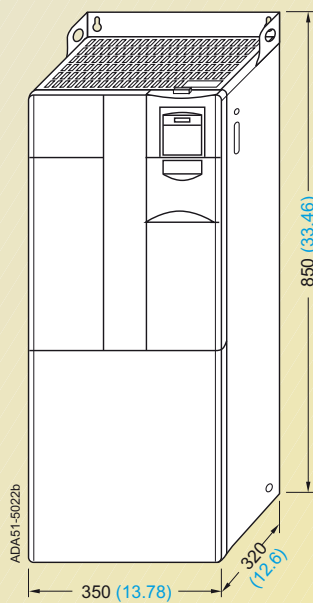


Inverter frame size E



Fixing with
4 x M8 bolts, 4 x M8 nuts,
4 x M8 washers

Tightening torque with washers
fitted: 13 Nm
Ventilation clearance required
Top and bottom: 300 mm

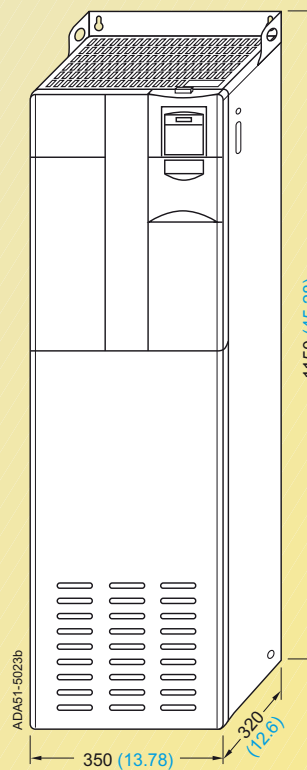


**Inverter frame size F
without filter**

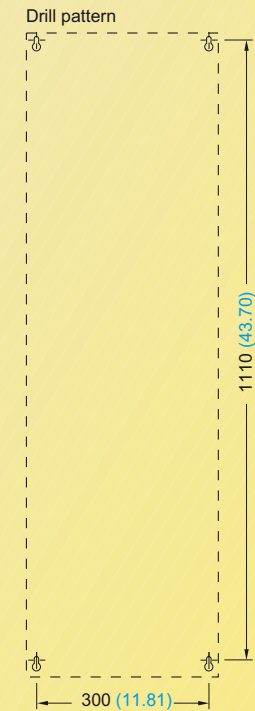


Fixing with
4 x M8 bolts, 4 x M8 nuts,
4 x M8 washers

Tightening torque with washers
fitted: 13 Nm
Ventilation clearance required
Top and bottom: 350 mm



**Inverter frame size F
with filter**



Fixing with
4 x M8 bolts, 4 x M8 nuts,
4 x M8 washers

Tightening torque with washers
fitted: 13 Nm
Ventilation clearance required
Top and bottom: 350 mm

All dimensions in mm (values in brackets are in inches)

MICROMASTER 440

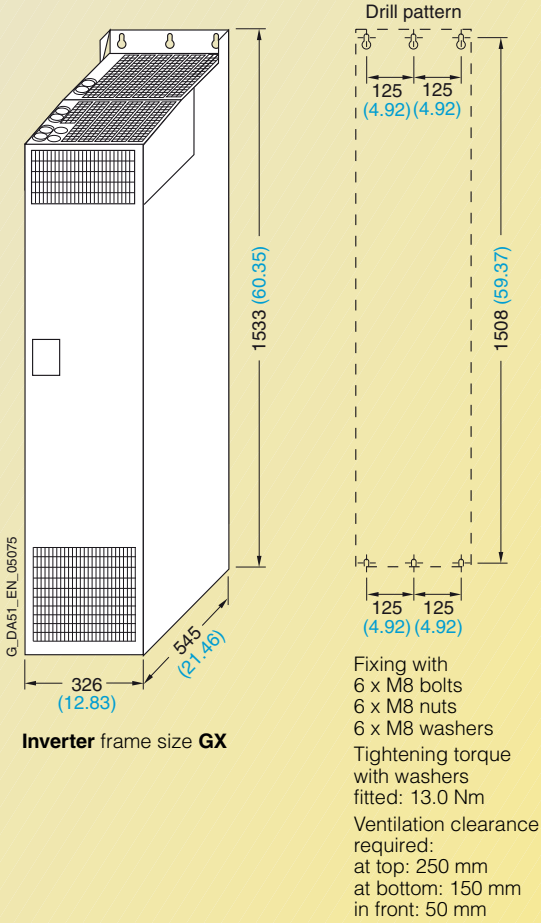
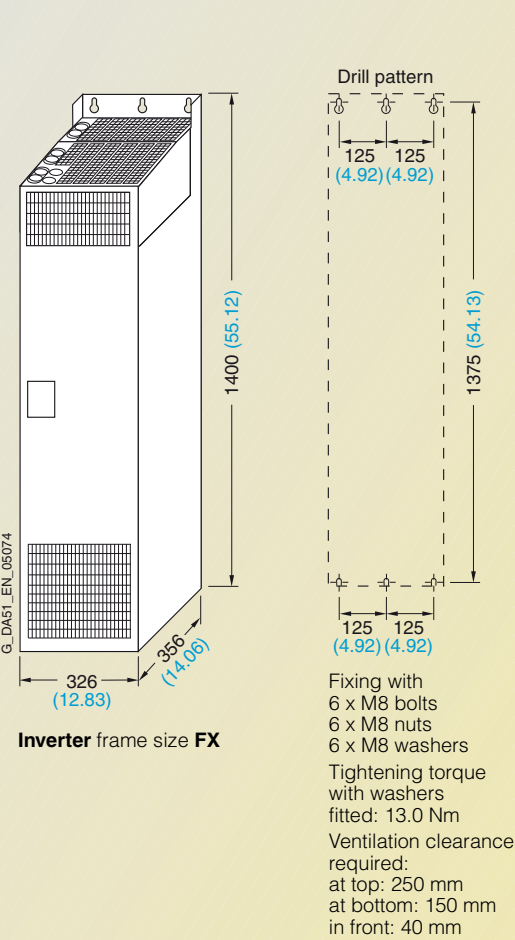
Dimension drawings

MICROMASTER 440 inverter (continued)

Frame size	3 AC 380 V to 480 V
FX	90 kW to 110 kW
GX	132 kW to 200 kW

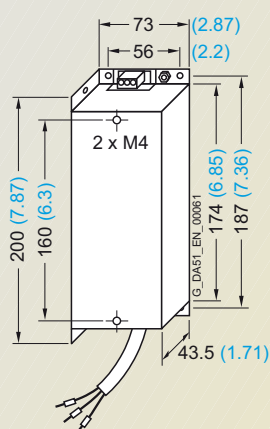
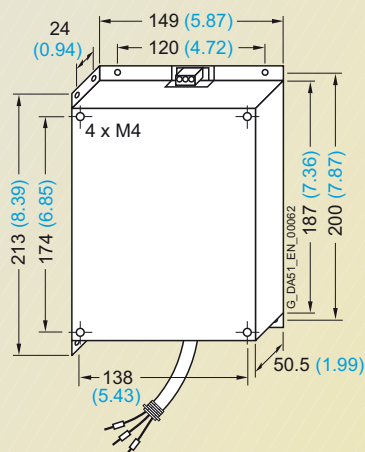
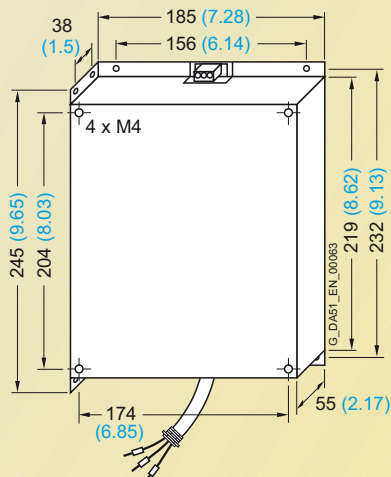
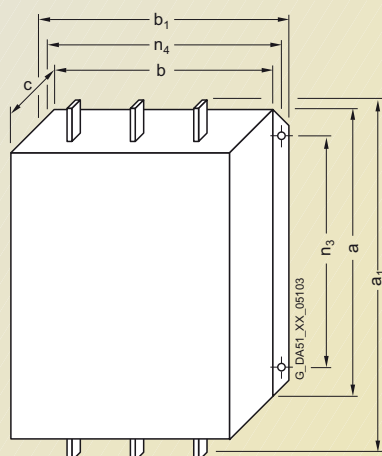
Note:
The inverters must not be mounted horizontally. But the inverters can be mounted without lateral spacing.

The specified outputs are valid for CT mode.



All dimensions in mm (values in brackets are in inches)

EMC filter

EMC filter for frame size **A**For frame size **B**For frame size **C**

EMC filter Class A Type 6SL3000-	for inverter Frame size (FS)	Dimensions							Weight, approx kg
		a	a ₁	b	b ₁	c	n ₃	n ₄	
OBE32-5AA0	FX	270 (10.63)	360 (14.17)	200 (7.87)	240 (9.45)	116 (4.57)	210 (8.27)	220 (8.66)	12.3
OBE34-4AA0	FX/GX	270 (10.63)	360 (14.17)	200 (7.87)	240 (9.45)	116 (4.57)	210 (8.27)	220 (8.66)	12.3
OBE36-0AA0	GX	310 (12.2)	400 (15.75)	215 (8.46)	265 (10.43)	140 (5.51)	250 (9.84)	240 (9.45)	19.0

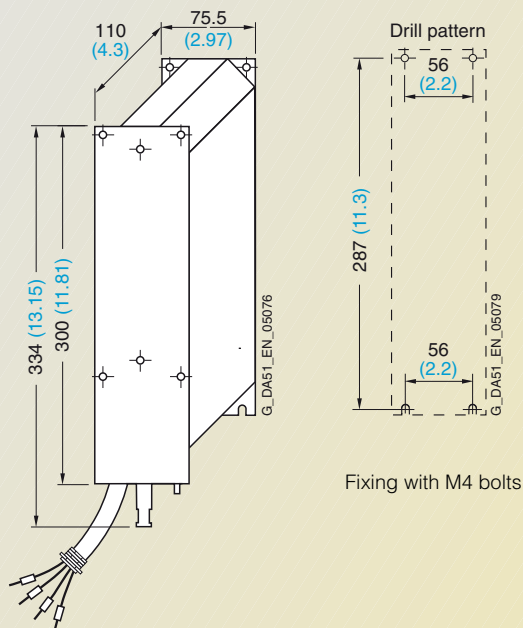
EMC filter for frame sizes **FX** and **GX**

All dimensions in mm (values in brackets are in inches)

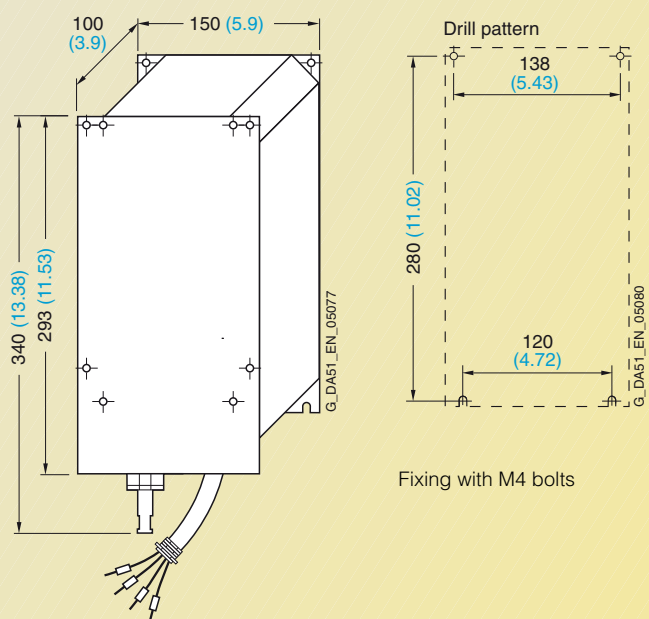
MICROMASTER 440

Dimension drawings

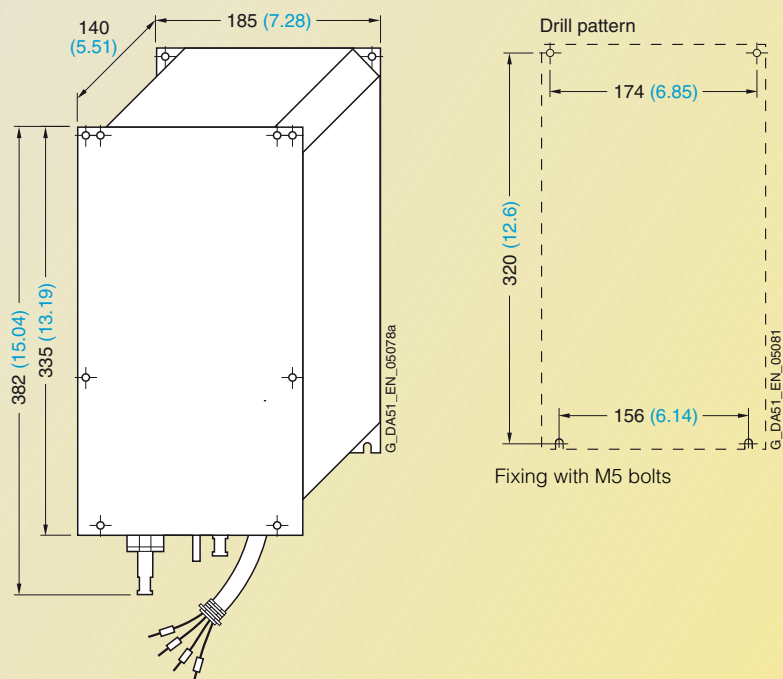
LC filter



LC filter for frame size **A**



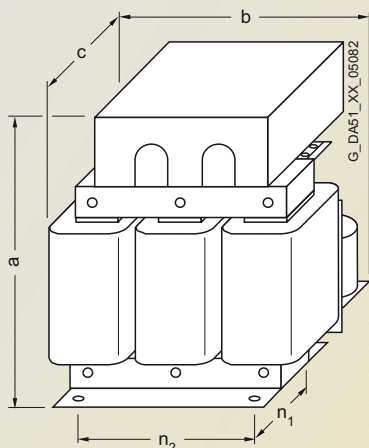
For frame size **B**



LC filter for frame size **C**

All dimensions in mm (values in brackets are in inches)

LC filter



Fixing with M10 bolts

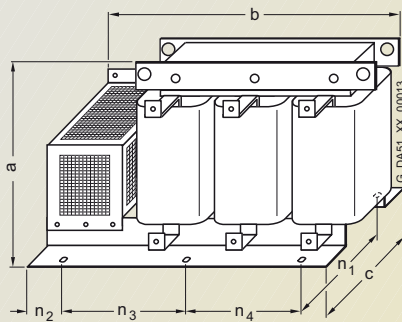
LC filter for frame sizes **D** to **F**

LC filter Type	for inverter Frame size (FS)	Dimensions					Weight, approx kg
		a	b	c	n ₁	n ₂	
6SE6400-3TD03-7DD0	D	278 (10.94)	240 (9.45)	230 (9.06)	115 (4.53)	190 (7.48)	21.0
6SE6400-3TD04-8DD0	D	290 (11.42)	240 (9.45)	240 (9.45)	125 (4.92)	190 (7.48)	26.0
6SE6400-3TD06-1DD0	D	345 (13.58)	300 (11.81)	220 (8.66)	120 (4.72)	240 (9.45)	34.0
6SE6400-3TD02-3DE0	D	280 (11.02)	240 (9.45)	240 (9.45)	125 (4.92)	190 (7.48)	26.1
6SE6400-3TD03-2DE0	D	300 (11.81)	300 (11.81)	235 (9.25)	133 (5.24)	240 (9.45)	39.5
6SE6400-3TD03-7DE0	D	310 (12.2)	300 (11.81)	250 (9.84)	145 (5.71)	240 (9.45)	42.0
6SE6400-3TD07-2ED0	E	355 (13.98)	300 (11.81)	235 (9.25)	145 (5.71)	240 (9.45)	49.5
6SE6400-3TD04-8EE0	E	345 (13.58)	300 (11.81)	260 (10.24)	160 (6.3)	240 (9.45)	48.5
6SE6400-3TD06-1EE0	E	345 (13.58)	300 (11.81)	275 (10.83)	171 (6.73)	240 (9.45)	57.5
6SE6400-3TD11-5FD0	E/F	460 (18.11)	360 (14.17)	235 (9.25)	125 (4.92)	264 (10.39)	67.0
6SE6400-3TD15-0FD0	F	460 (18.11)	360 (14.17)	250 (9.84)	140 (5.51)	264 (10.39)	75.0
6SE6400-3TD18-0FD0	F	520 (20.47)	420 (16.54)	290 (11.42)	173 (6.81)	316 (12.44)	77.5
6SE6400-3TD07-1FE0	F	380 (14.96)	300 (11.81)	285 (11.22)	171 (6.73)	240 (9.45)	70.5
6SE6400-3TD10-0FE0	F	460 (18.11)	360 (14.17)	250 (9.84)	140 (5.11)	264 (10.39)	70.5
6SE6400-3TD11-5FE0	F	515 (20.28)	420 (16.54)	290 (11.42)	173 (6.81)	316 (12.44)	125.5

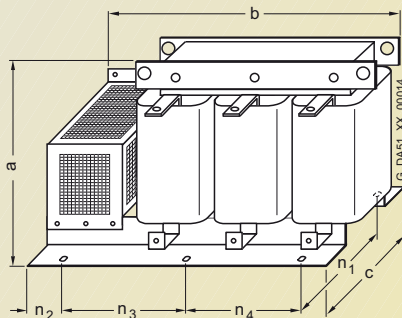
All dimensions in mm (values in brackets are in inches)

Dimension drawings

Sinusoidal filter

Sinusoidal filter for frame sizes **FX** and **GX**

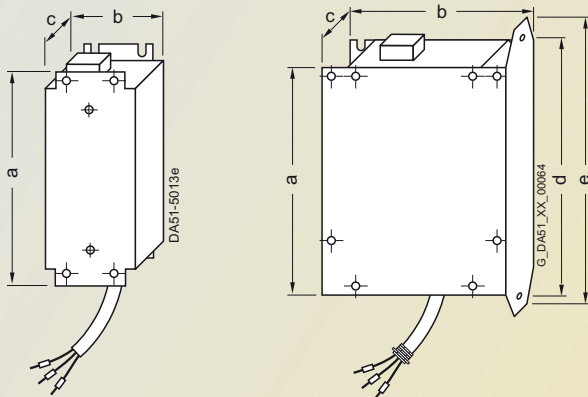
Sinusoidal filter Type 6SL3000-	for inverter Frame size (FS)	Dimensions							Weight (max.) kg
		a	b	c	n ₁	n ₂	n ₃	n ₄	
2CE32-3AA0	FX	300 (11.81)	620 (24.41)	320 (12.6)	280 (11.02)	105 (4.13)	225 (8.86)	150 (5.91)	135.0
2CE32-8AA0	GX	300 (11.81)	620 (24.41)	320 (12.6)	280 (11.02)	105 (4.13)	225 (8.86)	150 (5.91)	138.0

Sinusoidal filter for frame size **GX**

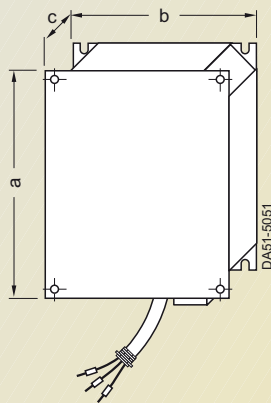
Sinusoidal filter Type 6SL3000-	for inverter Frame size (FS)	Dimensions							Weight (max.) kg
		a	b	c	n ₁	n ₂	n ₃	n ₄	
2CE33-3AA0	GX	370 (14.57)	620 (24.41)	360 (14.17)	320 (12.6)	105 (4.13)	225 (8.86)	150 (5.91)	144.0
2CE34-1AA0	GX	370 (14.57)	620 (24.41)	360 (14.17)	320 (12.6)	105 (4.13)	225 (8.86)	150 (5.91)	208.0

All dimensions in mm (values in brackets are in inches)

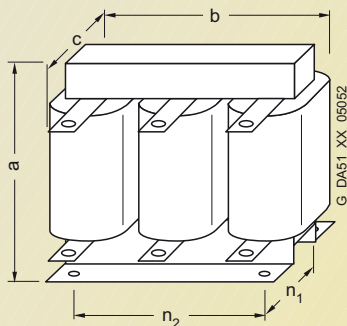
Line commutating chokes

Line commutating choke
for frame size **A**For frame sizes **B** and **C**

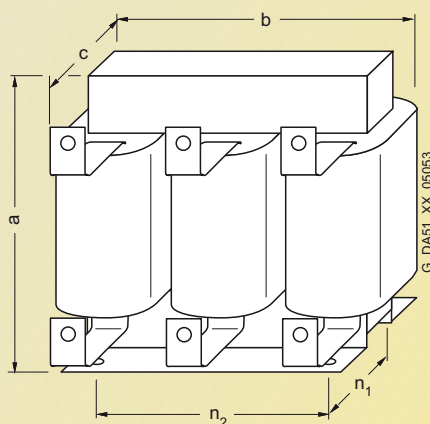
Line commutating choke for	Dimensions					Weight (max.) kg
	a	b	c	d	e	
Frame size A	200 (7.87)	75.5 (2.97)	50 (1.97)	–	–	1.4
Frame size B	213 (8.39)	150 (5.91)	50 (1.97)	220 (8.66)	233 (9.17)	2.2
Frame size C (380–480 V)	245 (9.65)	185 (7.28)	50 (1.97)	264 (10.39)	280 (11.02)	5.1
Frame size C (500–600 V, 0.75–1.5 kW)	245 (9.65)	185 (7.28)	50 (1.97)	264 (10.39)	280 (11.02)	3.8
Frame size C (500–600 V, 2.2–4 kW)	245 (9.65)	185 (7.28)	50 (1.97)	264 (10.39)	280 (11.02)	4.0
Frame size C (500–600 V, 5.5–11 kW)	245 (9.65)	185 (7.28)	80 (3.15)	264 (10.39)	280 (11.02)	8.0

Line commutating choke for frame sizes **D** and **E**

Line commutating choke for	Dimensions			Weight (max.) kg
	a	b	c	
Frame size D	520 (20.47)	275 (10.83)	85 (3.35)	9.5
Frame size E	650 (25.59)	275 (10.83)	95 (3.74)	17.0

Line commutating choke for inverter frame size **F**

Line commutating choke Type 6SE6400-	for inverter Frame size (FS)	Dimensions					Weight (max.) kg
		a	b	c	n ₁	n ₂	
3CC11-....	F	228 (8.98)	240 (9.45)	141 (5.55)	95 (3.74)	185 (7.28)	25.0

Line commutating choke for inverters of frame sizes **FX** and **GX**

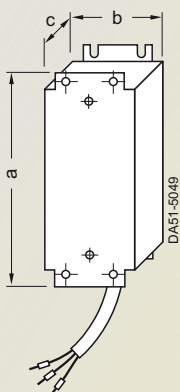
Line commutating choke Type 6SL3000-	for inverter Frame size (FS)	Dimensions					Weight (max.) kg
		a	b	c	n ₁	n ₂	
0CE32-....	FX	248 (9.76)	255 (10.04)	203 (7.99)	101 (3.98)	200 (7.87)	24.0
0CE33-....	GX	248 (9.76)	255 (10.04)	203 (7.99)	101 (3.98)	200 (7.87)	25.0
0CE35-....	GX	269 (10.59)	275 (10.83)	210 (8.27)	118 (4.65)	224 (8.82)	35.0

All dimensions in mm (values in brackets are in inches)

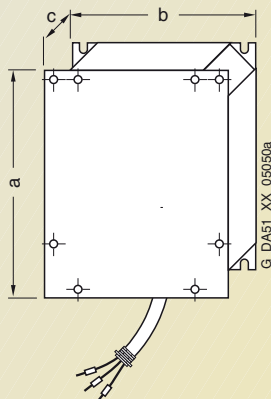
MICROMASTER 440

Dimension drawings

Output chokes

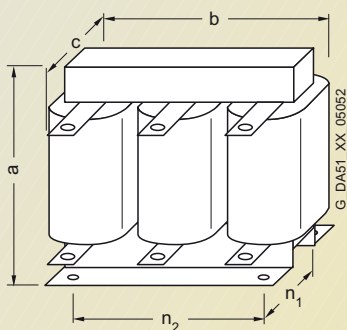


Output choke
for frame size **A**
6SE6400-3TC00-4AD2
6SE6400-3TC00-4AD3



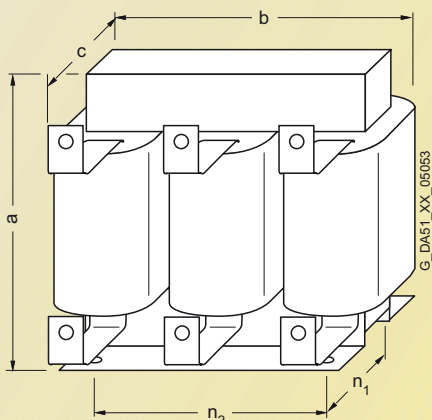
For frame sizes **B** and **C**
6SE6400-3TC01-0BD3
6SE6400-3TC01-8CE3
6SE6400-3TC03-2CD3

Output choke Type 6SE6400-	Dimensions			Weight (max.) kg
	a	b	c	
3TC00-4AD2	200 (7.87)	75.5 (2.97)	110 (4.33)	1.9
3TC00-4AD3	200 (7.87)	75.5 (2.97)	50 (1.97)	1.3
3TC01-0BD3	213 (8.39)	150 (5.91)	80 (3.15)	4.1
3TC01-8CE3	245 (9.65)	185 (7.28)	110 (4.33)	10.8
3TC03-2CD3	245 (9.65)	185 (7.28)	80 (3.15)	6.6



Output chokes
for inverters of frame sizes **D, E** and **F**

Output choke Type 6SE6400-	for inverter Frame size (FS)	Dimensions			to DIN 41 308		Weight (max.) kg
		a	b	c	n ₁	n ₂	
3TC03-2DE0	D	210 (8.27)	225 (8.86)	179 (7.05)	94 (3.70)	176 (6.93)	16.0
3TC03-8DD0	D	210 (8.27)	225 (8.86)	179 (7.05)	94 (3.70)	176 (6.93)	16.1
3TC05-4DD0	D	210 (8.27)	225 (8.86)	150 (5.91)	70 (2.76)	176 (6.93)	10.7
3TC06-2FE0	F	269 (10.59)	300 (11.81)	220 (8.66)	118 (4.65)	224 (8.82)	33.9
3TC07-5ED0	E	248 (9.76)	270 (10.63)	209 (8.23)	101 (3.98)	200 (7.87)	24.9
3TC08-0ED0	E	210 (8.27)	225 (8.86)	150 (5.91)	70 (2.76)	176 (6.93)	10.4
3TC08-8FE0	F	321 (12.64)	350 (13.78)	288 (11.34)	138 (5.43)	264 (10.39)	51.5
3TC14-5FD0	F	321 (12.64)	350 (13.78)	288 (11.34)	138 (5.43)	264 (10.39)	51.5
3TC15-4FD0	F	248 (9.76)	270 (10.63)	209 (8.23)	101 (3.98)	200 (7.87)	24.0



Output chokes
for inverters of frame sizes **FX** and **GX**

Output choke Type 6SL3000-	for inverter Frame size (FS)	Dimensions					Weight (max.) kg
		a	b	c	n ₁	n ₂	
2BE32-1AA0	FX	285 (11.22)	300 (11.81)	257 (10.12)	163 (6.42)	224 (8.82)	60.0
2BE32-6AA0	FX	315 (12.4)	300 (11.81)	277 (10.91)	183 (7.2)	224 (8.82)	66.0
2BE33-2AA0	GX	285 (11.22)	300 (11.81)	257 (10.12)	163 (6.42)	224 (8.82)	62.0
2BE33-8AA0	GX	285 (11.22)	300 (11.81)	277 (10.91)	183 (7.2)	224 (8.82)	73.0
2BE35-0AA0	GX	365 (14.37)	300 (11.81)	277 (10.91)	183 (7.2)	224 (8.82)	100.0

All dimensions in mm (values in brackets are in inches)

Brake resistors

Fig. 1:

Frame sizes A, B
Frame sizes C, D, E, F

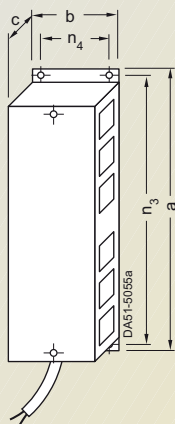


Fig. 2:

Fastening hole: circular hole Ø 5.2 mm
Fastening hole: slotted hole 6 x 12 mm
or circular hole Ø 6.5 mm
) Circular hole Ø 9 mm
1) Only for SINAMICS G120

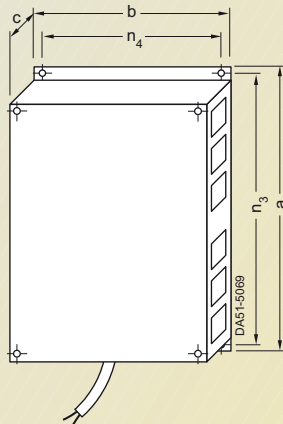
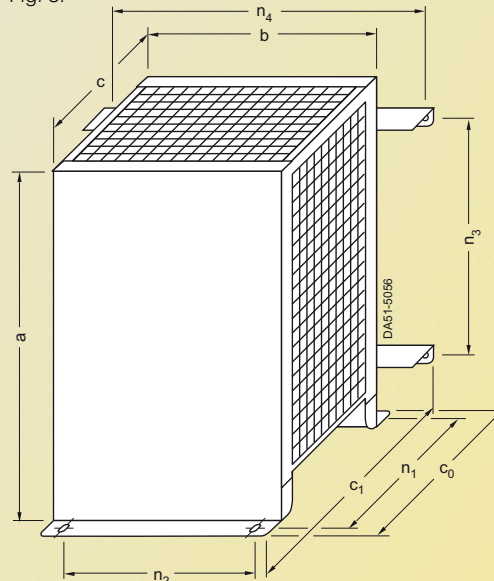


Fig. 3:



Brake resistors Type 6SE6400-	Resistor Ohm	for inverter Frame size (FS)	Figure No.	Dimensions					For floor mounting		For wall mounting		Weight (max.) kg
				a	b	c	c ₀	c ₁	n ₁	n ₂	n ₃	n ₄	
4BC05-0AA0	180	A	1	230 (9.06)	72 (2.83)	43.5 (1.71)	—	—	—	—	217 (8.54)	56 (2.20)	1.0
4BC11-2BA0	68	B	2	239 (9.41)	149 (5.87)	43.5 (1.71)	—	—	—	—	226 (8.90)	133 (5.24)	1.6
4BC12-5CA0	39	C	3	285 (11.22)	185 (7.28)	150 (5.91)	185 (7.28)	217 (8.54)	170 (6.69)	145 (5.71)	200 (7.87)	230 (9.06)	3.8
4BC13-0CA0	27	C	3	285 (11.22)	185 (7.28)	150 (5.91)	185 (7.28)	217 (8.54)	170 (6.69)	145 (5.71)	200 (7.87)	230 (9.06)	3.8
4BC18-0DA0	10	D	3	515 (20.28)	270 (10.63)	175 (6.89)	210 (8.27)	242 (9.53)	195 (7.68)	205 (8.07)	350 (13.78)	315 (12.40)	7.4
4BC21-2EA0	6.8	E	3	645 (25.39)	270 (10.63)	175 (6.89)	210 (8.27)	242 (9.53)	195 (7.68)	205 (8.07)	480 (18.90)	315 (12.40)	10.6
4BC22-5FA0	3.3	F	3	650 (25.59)	395 (15.55)	315 (12.40)	350 (13.78)	382 (15.04)	335 (13.19)	270 (10.63)	510 (20.08)	435 (17.13)	16.7
4BD11-0AA0	390	A	1	230 (9.06)	72 (2.83)	43.5 (1.71)	—	—	—	—	217 (8.54)	56 (2.20)	1.0
4BD12-0BA0	160	B	2	239 (9.41)	149 (5.87)	43.5 (1.71)	—	—	—	—	226 (8.90)	133 (5.24)	1.6
4BD16-5CA0	56	C	3	285 (11.22)	185 (7.28)	150 (5.91)	185 (7.28)	217 (8.54)	170 (6.69)	145 (5.71)	200 (7.87)	230 (9.06)	3.8
4BD21-2DA0	27	D	3	515 (20.28)	270 (10.63)	175 (6.89)	210 (8.27)	242 (9.53)	195 (7.68)	205 (8.07)	350 (13.78)	315 (12.40)	7.4
4BD22-2EA1	15	E *)	3	301 (11.85)	326 (12.83)	484 (19.06)	484 (19.06)	—	380 (14.96)	300 (11.81)	—	—	11.0
4BD24-0FA0	8.2	F	3	650 (25.59)	395 (15.55)	315 (12.40)	350 (13.78)	382 (15.04)	335 (13.19)	270 (10.63)	510 (20.08)	435 (17.13)	16.7
4BD26-0FA0 ¹⁾	5.5	F *)	3	301 (11.85)	526 (20.71)	484 (19.06)	484 (19.06)	—	380 (14.96)	500 (19.69)	—	—	17.5
4BE14-5CA0	120	C	3	285 (11.22)	185 (7.28)	150 (5.91)	185 (7.28)	217 (8.54)	170 (6.69)	145 (5.71)	200 (7.87)	230 (9.06)	3.8
4BE16-5CA0	82	C	3	285 (11.22)	185 (7.28)	150 (5.91)	185 (7.28)	217 (8.54)	170 (6.69)	145 (5.71)	200 (7.87)	230 (9.06)	3.8
4BE21-3DA0	39	D	3	515 (20.28)	270 (10.63)	175 (6.89)	210 (8.27)	242 (9.53)	195 (7.68)	205 (8.07)	350 (13.78)	315 (12.40)	7.4
4BE21-8EA0	27	E	3	645 (25.39)	270 (10.63)	175 (6.89)	210 (8.27)	242 (9.53)	195 (7.68)	205 (8.07)	480 (18.90)	315 (12.40)	10.6
4BE24-2FA0	12	F	3	650 (25.59)	395 (15.55)	315 (12.40)	350 (13.78)	382 (15.04)	335 (13.19)	270 (10.63)	510 (20.08)	435 (17.13)	16.7

Brake resistors for inverters of frame sizes **A** to **F**

All dimensions in mm (values in brackets are in inches)

Notes

MICROMASTER 420/430/440

Appendix



A/2	Environment, resources and recycling
A/2	Certificates
A/4	Compliance with standards
A/6	Drive ES engineering system
A/7	Demonstration case
A/7	Standard conversion factors: metric to US units
A/8	Training
A/9	Overview of SIMATIC ET 200S FC/ ET 200pro FC
A/11	Overview of SINAMICS G110, G120, G120D
A/14	Overview of IEC squirrel-cage motors
A/17	Overview of MICROMASTER 411 and COMBIMASTER 411
A/18	Overview of NEMA motors
A/19	Siemens contacts worldwide
A/20	Online services
A/21	Service & Support
A/22	Subject index
A/23	Order No. index Notes on ordering
A/24	Conditions of sale and delivery Export regulations

Appendix

Environment, resources and recycling

Siemens AG feels a responsibility to play a role in protecting our environment and saving our valuable natural resources. This is true for both our production and our products.

Even during development, we consider any possible environmental impact of future products/systems. Our aim is to prevent harmful environmental effects or at least to reduce them to an absolute minimum – beyond present regulations and legislation.

The most important activities for protecting our environment are as follows:

- We are constantly endeavoring to reduce the environmental impact of our products as well as their consumption of energy and resources over and above the statutory environmental protection regulations.
- We take every possible step to prevent damage to the environment.
- Environmental impact is assessed and considered at the earliest possible stage of product and process planning.
- Our optimized environmental management strategy ensures that our environmental policy is put into practice effectively. The necessary technical and organizational procedures are reviewed at regular intervals and continuously updated.
- An awareness for environmental problems is expected of all our employees. Establishing and furthering a sense of responsibility for the environment on all levels represents a permanent challenge for the corporate management.

- We urge our business partners to act according to the same environmental principles as ourselves. We co-operate with the responsible public authorities.
- We inform interested members of the public about the consequences of our corporate policies for the environment as well as our achievements to the benefit of the environment.
- Our complete documentation is printed on chlorine-free bleached paper.

Certificates



Certificates (continued)

SIEMENS

EG-Konformitätserklärung
664.20001.21

Hersteller: **Siemens AG
Automation and Drives
Standard Drives**

Anschrift: **Frauenauracherstr. 80
91056 Erlangen
Germany**

Produktbezeichnung: **MICROMASTER 410 / 6SE6410-.....-X*..
MICROMASTER 420 / 6SE6420-.....-X*..
MICROMASTER 430 / 6SE6430-.....-X*..
MICROMASTER 440 / 6SE6440-.....-X*..**

* Baugrößen A bis G

Das bezeichnete Produkt stimmt mit den Vorschriften folgender Europäischer Richtlinie überein:

73/23/EWG Richtlinie des Rates zur Angleichung der Rechtsvorschriften der Mitgliedstaaten betreffend elektrischer Betriebsmittel zur Verwendung innerhalb bestimmter Spannungsgrenzen, geändert durch RL 93/68/EWG des Rates

Die Übereinstimmung mit den Vorschriften dieser Richtlinie wird nachgewiesen durch die Einhaltung folgender Normen:

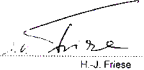
EN 61800-5-1: 2003¹⁾ EN 60204-1: 1998

¹⁾ Abweichungen zu den Forderungen der EN 61800-5-1 sind in einem technischen Bericht zur Risikobewertung dokumentiert.

Das bezeichnete Produkt ist zum Einbau in eine andere Maschine bestimmt. Die Inbetriebnahme ist solange untersagt, bis die Konformität des Endproduktes mit der Richtlinie 98/37/EG festgestellt ist.

Erstausgabe: 30.10.2002
Erlangen, 31.07.2006


G. Bock
Head of Research and Development Drives & Motors


H.-J. Friese
Head of Quality Management

Diese Erklärung bescheinigt die Übereinstimmung mit den genannten Richtlinien, ist jedoch keine Beschaffenheits- oder Haltbarkeitsgarantie nach §443 BGB. Die Schließbzw. der mitgelieferten Produktdokumentation sind zu beachten.

Legend for EC declaration of conformity:

The named product is in conformity with the requirements of the following European Directive:

73/23/EEC Council Directive on the approximation of the laws of the Member States relating to electrical equipment for use within certain voltage limits, amended by Council Directive RL 93/68/EEC

Conformity with the requirements of this Directive is testified by adherence to the following standards:

EN 61800-5-1: 2003¹⁾

The named product is intended for fitting in another machine. Commissioning is prohibited until such time as the end product has been proved to conform to the provisions of Directive 98/37/EC. This declaration certifies compliance with the Directives named above, but does not guarantee any specific properties or durability according to §443 BGB. The safety information and instructions in the supplied product documentation must be carefully observed.

1) Deviations to the requirements listed in EN 61800-5-1 must be documented in a technical report on the risk assessment.

Appendix

Compliance with standards

CE marking



The MICROMASTER inverters meet the requirements of the Low-Voltage Directive 73/23/EEC.

Low-voltage directive

The inverters comply with the following standards listed in the Official Journal of the European Communities:

• EN 60 204

Safety of machinery, electrical equipment of machines

• EN 61 800-5-1

Electrical power drive systems with variable speed – Part 5-1: Requirements regarding safety - electrical, thermal and energy requirements

Machine directive

The inverters are suitable for installation in machines. Compliance with the machine directive 89/392/EEC requires a separate certificate of conformity. This must be furnished by the plant constructor or the installer of the machine.

EMC directive

• EN 61 800-3

Variable-speed electric drives Part 3: EMC product standard including special test procedure.

The new EMC product standard EN 61 800-3 applies to electrical drive systems as of July 1, 2005. The transition period for the preceding standard EN 61 800-3/A11 dated February 2001 ends on October 1, 2007. The following explanations apply to frequency inverters of the 6SE6 series from Siemens:

- The EMC product standard EN 61 800-3 does not apply directly to a frequency inverter but to a PDS (Power Drive System), which comprises the complete circuitry, motor and cables in addition to the inverter.

- As a rule, frequency inverters are only supplied to qualified technical specialists for installation in machines or plants. A frequency inverter must therefore only be considered as a component which, as such, is not subject to the EMC product standard EN 61 800-3. However, the inverter's instruction manual specifies the conditions under which the product standard can be complied with if the frequency inverter is expanded to become a PDS. For a PDS, the EMC directive in the EU is complied with through observance of the product standard EN 61 800-3 for variable-speed electrical drive systems. The frequency inverters on their own do not generally require marking according to the EMC directive.

- The new EN 61 800-3 of July 2005 no longer distinguishes between "general availability" and "restricted availability". Instead, different categories, namely C1 to C4, are defined according to the environment of the PDS at the place of use:

– Category C1:

Drive systems for rated voltages of < 1000 V for use in the first environment

– Category C2:

Fixed-location drive systems which are not connected by means of plug-in devices, for rated voltages of < 1000 V. If used in the first environment, installation and start-up may only be carried out by qualified EMC personnel. Warning information must be provided.

– Category C3:

Drive systems for rated voltages of < 1000 V, solely for use in the second environment. Warning information must be provided.

– Category C4:

Drive systems for rated voltages of ≥ 1000 V or for rated currents of ≥ 400 A or for use in complex systems in the second environment. An EMC plan must be drawn up.

- In the EMC product standard EN 61 800-3, limits for conducted interference voltages and radiated interference are also indicated for the so-called "second environment" (= industrial power supply systems which do not supply households). These limits are lower than the limits of filter class A according to EN 55 011. The use of unfiltered inverters in an industrial environment is permissible provided they are part of a system that is equipped with line filters on the higher-level infeed side.
- With MICROMASTER, power drive systems (PDS) which comply with EMC product standard EN 61 800-3 can be installed (see the installation instructions in the product documentation). The table entitled "Overview of MICROMASTER components and PDS categories" and the MICROMASTER ordering documents show which components the respective PDS installation supports directly.
- In general, a distinction must be made between the product standards for electrical drive systems (PDS) of the EN 61 800 series of standards (of which Part 3 covers EMC topics) and the product standards for devices/systems/machines etc. This will probably not result in any changes in the practical use of frequency inverters. Since frequency inverters are always part of a PDS and the latter is part of a machine, the manufacturer of the machine must observe various standards depending on the type of machine and the environment, e.g. EN 61 000-3-2 for power supply harmonics and EN 55 011 for radio interference. The PDS product standard alone is therefore inadequate or irrelevant.
- With regard to compliance with limits for power supply harmonics, the EMC product standard EN 61 800-3 for PDS refers to compliance with the EN 61 000-3-2 and EN 61 000-3-12 standards.
- Irrespective of configuration with MICROMASTER and its components, the machine builder can also modify the machines in other ways in order to comply with the EMC directive of the EU. As a rule, the EMC directive of the EU is observed through compliance with the EMC product standards applicable to the machine. If they are not available, the generic standards such as DIN EN 61 000-x-x can be used instead. What is important is that the conducted interference and the radiated interference voltages at the power-supply connection point and outside the machine remain below the corresponding limits. What technical means are used to ensure this is not prescribed.

Overview of MICROMASTER components and PDS categories

First environment (residential, commercial)	Category C1	Second environment (industrial)
	Unfiltered devices plus external Class B filter with low leakage currents	
	Category C2 Devices with an integrated Class B filter or devices with an integrated Class A filter plus external supplementary filter Class B or devices with an integrated Class A filter plus warning information or unfiltered devices plus external Class A filter plus warning information	
	Category C3 Devices with integrated Class A filter or unfiltered devices plus external Class A filter Warning information is necessary. Note: The requirements of EN 61 800-3 are considerably exceeded if Class A filters are used.	
	Category C4 Unfiltered devices plus external Class A filter An EMC plan must be drawn up. Note: The requirements of EN 61 800-3 are considerably exceeded if Class A filters are used.	

Electromagnetic
compatibility

No inadmissible electromag-
netic emissions occur if the in-
stallation instructions specific
to the product are correctly
observed.

The table below lists the
results of measurements
relating to the emissions and
immunity to interference of
MICROMASTER inverters.

The inverters were installed
with shielded motor cables
and shielded control cables in
accordance with the direc-
tives.

EMC phenomenon Standard/test		Relevant criteria	Limit value
Emitted interference EN 61 800-3	Conducted via mains cable	150 kHz to 30 MHz	Unfiltered devices, not tested. All devices with an internal/external filter: Depending on the type of filter and on the envisaged PDS installation: Category C1: Limit value complies with EN 55 011, Class B Category C2: Limit value complies with EN 55 011, Class A, Group 1. In addition, all devices with an internal/external filter comply with the limit value for category C3 installations. Limit value complies with EN 55 011, Class A, Group 2.
	Emitted by the drive	30 MHz to 1 GHz	All devices. Limit value complies with EN 55 011, Class A, Group 1.
ESD immunity EN 61 000-4-2	ESD through air discharge ESD through contact discharge	Test severity level 3 Test severity level 3	8 kV 6 kV
Immunity to electrical fields EN 61 000-4-3	Electrical field applied to unit	Test severity level 3 80 MHz to 1 GHz	10 V/m
Immunity to burst interference EN 61 000-4-4	Applied to all cable terminations	Test severity level 4	4 kV
Surge immunity EN 61 000-4-5	Applied to mains cables	Test severity level 3	2 kV
Immunity to RFI emissions, conducted EN 61 000-4-6	Applied to mains, motor and control cables	Test severity level 3 0.15 MHz to 80 MHz 80 % AM (1 kHz)	10 V

UL listing



® and c® listed power conversion equipment of ® category NMMS,
in accordance with UL508C.

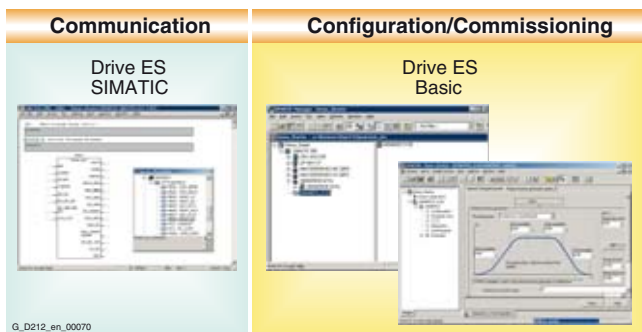
® list number E121068 and E192450

For use in environments with pollution degree 2.

Also refer to the Internet at
<http://www.ul.com>

Appendix

Drive ES engineering system



Drive ES is the engineering system used to integrate Siemens drive technology into the SIMATIC automation world easily, efficiently and cost-effectively in terms of communication, configuration and data management. The STEP 7 Manager user interface provides the basis for this procedure.

Various software packages are available for MICROMASTER:

- **Drive ES Basic** for first-time users of the world of Totally Integrated Automation and the option for routing beyond network limits and the use of the SIMATIC teleservice.

Drive ES Basic is the basic software program for setting the parameters of all drives online and offline.

Drive ES Basic processes the automated system and drives on the interface of the SIMATIC Manager. Drive ES Basic is the starting point for common data archiving for complete projects and for extending the use of the SIMATIC teleservice to drives. Drive ES Basic provides the engineering tools for the new motion control functions – peer-to-peer data traffic, equidistance and isochronous operation with PROFIBUS DP.

- **Drive ES SIMATIC**

Simply parameterize the STEP 7 communication instead of programming. In order to use Drive ES SIMATIC STEP 7 must be installed. It features a SIMATIC function block library, thereby making the programming of the PROFIBUS interface in the SIMATIC-CPU for the drives easy and secure.

There is no need for separate, time-consuming programming of the data exchange between the SIMATIC-CPU and the drive.

All Drive ES users need to remember is:

Copy – Modify – Load – Finished.

Customized, **fully-developed function blocks** are copied from the library into user-specific projects. Frequently-used functions are set to run in program format:

- Read out complete diagnostics buffer automatically from the drive
- Complete parameter sets are automatically downloaded into the drive from the SIMATIC CPU – e.g. when a device has to be replaced

- Part parameter sets (e.g. for recipe and product change) are automatically downloaded into the drive from the SIMATIC-CPU
- Complete parameterization or part parameter sets are uploaded from the drive into the SIMATIC-CPU, i.e. updated.

- **Drive ES PCS 7**

integrates drives with the PROFIBUS interface into the SIMATIC PCS 7 process control system.

Drive ES PCS 7 can only be used with SIMATIC PCS 7 Version 5.2 and higher.

Drive ES PCS 7 provides a function block library with function blocks for the drives and the corresponding faceplates for the operator station, which enables the drives to be operated from the PCS 7 process control system.

For further information please visit us on the Internet at:

<http://www.siemens.com/drivesolutions>

Selection and ordering data

Description		Software	Order No.
Drive ES Basic V 5.4		Single license	6SW1700-5JA00-4AA0
• Configuration software for the integration of drives into Totally Integrated Automation	• Requirement: STEP 7 V 5.3 and higher, SP3	Multi-user license, 60 pieces	6SW1700-5JA00-4AA1
	• Supply format: on CD-ROM de, en, fr, es, it with electronic documentation	Update service for single-user license	6SW1700-0JA00-0AB2
		Update service for multi-user license	6SW1700-0JA00-1AB2
		Upgrade from V 5.x to V 5.4	6SW1700-5JA00-4AA4
Drive ES SIMATIC V 5.4		Single-user license incl. 1 x runtime license	6SW1700-5JC00-4AA0
• Function block library for SIMATIC for the parameterization of communication with the drives	• Requirement: STEP 7 V 5.3 and higher, SP3	Runtime license	6SW1700-5JC00-1AC0
	• Supply format: on CD-ROM de, en, fr, es, it with electronic documentation	Update service for single-user license	6SW1700-0JC00-0AB2
		Upgrade from V 5.x to V 5.4	6SW1700-5JC00-4AA4
Drive ES PCS 7 V 6.1		Single-user license incl. 1 x runtime license	6SW1700-6JD00-1AA0
• Function block library for PCS 7 for the integration of drives	• Requirement: PCS 7 V 6.1	Runtime license	6SW1700-5JD00-1AC0
	• Supply format: on CD-ROM de, en, fr, es, it with electronic documentation	Update service for single-user license	6SW1700-0JD00-0AB2
		Upgrade from V 5.x to V 6.1	6SW1700-6JD00-1AA4

Demonstration case

SIDEMO demonstration case system

The SIDEMO range of modular demonstration case systems also includes cases for the MICROMASTER inverters.

The MICROMASTER demonstration cases can be operated on 230 V supplies on their own or together with other demonstration systems such as LOGO!, SIMATIC S7-200, SITOP DC-UPS.

The demonstration systems are fitted in dark blue transport cases (400 x 300 x 210 mm). The transport cases can be stacked.

If the MICROMASTER 420/440 demonstration case is expanded with a PROFIBUS module (not included in scope of supply of the case), it is also possible to demonstrate incorporation into TIA in combination with the SIMATIC S7-300 Compact and Touchpanel TP170B demonstration systems.



SIDEMO demonstration case	Order No.	Weight, approx. kg
MICROMASTER 420 • including BOP operator panel	6AG1062-1AA02-0AA0	10
MICROMASTER 440 • including BOP operator panel	6AG1062-1AA02-1AA1	10
MICROMASTER 440 • including BOP operator panel • the motor is equipped with a load unit	6AG1062-1AA06-0AA0	10
MICROMASTER 440 • including BOP operator panel and pulse encoder evaluation module • the motor is equipped with an encoder and a load unit	6AG1062-1AA07-0AA0	10

Further information, e.g. **110 V versions**, is available on the Internet at: <http://www.siemens.de/sidemo>

Standard conversion factors: metric to US units

Unit	US to metric standard units	Metric to US standard units
Length	1 in. = 25.40 mm	1 mm = 0.03937 in.
	1 ft. = 30.48 cm	1 cm = 0.39370 in.
	1 yd. = 0.91 m	1 m = 3.28084 ft.
	1 mi. = 1.61 km	1 km = 0.62137 mi.
Temperature	°C = 5/9 (°F – 32)	°F = (9 x °C)/5 + 32
Weight	1 lbs = 0.454 kg	1 kg = 2.205 lbs
Torque	1 lb.ft. = 1.356 Nm	1 Nm = 0.738 lb.ft.
Power	1 hp = 0.746 kW	1 kW = 1.341 hp

Note:

For kW and hp specifications in the Selection and Ordering tables, we do not use calculated hp values but the corresponding standardized hp motor ratings.

MICROMASTER 420/430/440

Appendix

Faster and more applicable know-how: Hands-on training from the manufacturer

SITRAIN® – the Siemens Training for Automation and Industrial Solutions – provides you with comprehensive support in solving your tasks.

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Contact

Visit our site on the Internet at:

www.siemens.com/sitrain

or let us advise you personally. You can request our latest training catalog from:

SITRAIN Customer Support Germany:

Phone: +49 (0)1805 / 23 56 11
(0.14 €/min from the German landline network)

Fax: +49 (0)1805 / 23 56 12

SITRAIN highlights

Top trainers

Our trainers are skilled teachers with direct practical experience. Course developers have close contact with product development, and directly pass on their knowledge to the trainers.

Practical experience

The practical experience of our trainers enables them to teach theory effectively. But since theory can be pretty drab, we attach great importance to practical exercises which can comprise up to half of the course time. You can therefore immediately implement your new knowledge in practice. We train you on state-of-the-art methodically/didactically designed training equipment. This training approach will give you all the confidence you need.

Wide variety

With a total of about 300 local attendance courses, we train the complete range of A&D products as well as interaction of the products in systems. Telecourses, teach-yourself software and seminars with a presenter on the Web supplement our classic range of courses.

Tailor-made training

We are only a short distance away. You can find us at more than 50 locations in Germany, and in 62 countries worldwide. You wish to have individual training instead of one of our 300 courses? Our solution: We will provide a program tailored exactly to your personal requirements. Training can be carried out in our Training Centers or at your company.

The right mixture: Blended learning

“Blended learning” means a combination of various training media and sequences. For example, a local attendance course in a Training Center can be optimally supplemented by a teach-yourself program as preparation or follow-up. Additional effect: Reduced traveling costs and periods of absence.



Overview of frequency inverters/converters for SIMATIC ET 200 distributed I/O

Frequency inverters are available for the SIMATIC ET 200 distributed I/O that are fully system-integrated modules. Inverters are available for the finely modular SIMATIC ET 200S FC system to the IP20 degree of protection as well as for the cabinet-free SIMATIC ET 200pro FC system to the IP65 degree of protection.

With a broad range of possibilities, the frequency inverters expand the functional scope of the modular modules that are available in both systems (e.g. inputs and outputs, technology modules, direct and soft starters). With suitable interface modules, connection to PROFIBUS and PROFINET is possible via the ET 200

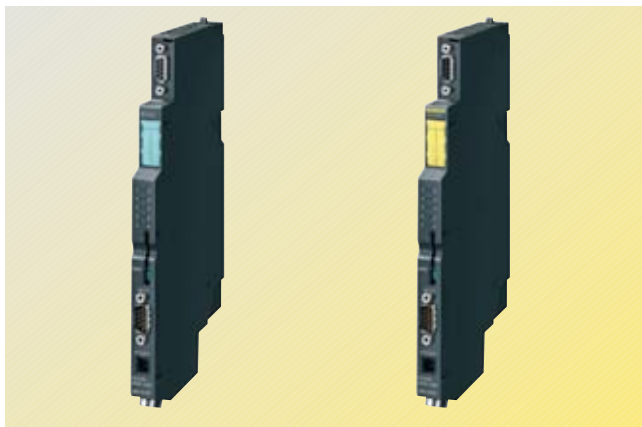
system bus as well as integration of PLC functionality into the system. Fail-safe frequency inverter functions can be activated locally or via PRO-Flsafe.

An overview of the features of the SIMATIC ET 200S FC frequency inverter series is given in the table below.

The complete product spectrum including ordering data, technical data and explanations can be found in Catalog IK PI "Industrial Communication for Automation and Drives" and on the Internet at

<http://www.siemens.com/et200s-fc>

SIMATIC ET 200S FC	
Main features	<ul style="list-style-type: none"> • Complete embedding of a frequency inverter into a distributed I/O system to IP20 degree of protection • Easy assembly and low susceptibility to errors thanks to self-assembling energy and communications bus • Space-saving assembly thanks to compact dimensions and common protection • Fast, tool-free replacement of the frequency inverter for a servicing requirement (hot swapping) • Frequency control (V/f), vector control with and without encoders • Line-commutated regenerative feedback by power electronics of the latest generation • Modular structure with Control Unit (closed-loop control module) and Power Module (power section) • Frequency inverter variant with integrated, autonomous, fail-safe functions without the need for complex external wiring
Rated outputs	0.75 kW, 2.2 kW, 4.0 kW
Input voltage	3 AC 380 ... 480 V $\pm 10\%$
Overall width	Control Unit + Power Module up to 0.75 kW: 80 mm, otherwise 145 mm
Mains frequency	47 ... 63 Hz
Overload capability	<ul style="list-style-type: none"> • Overload current $1.5 \times$ rated output current (i.e. 150% overload) over 60 s, cycle time 300 s • Overload current $2 \times$ rated output current (i.e. 200% overload) over 3 s, cycle time 300 s
Output frequency	0 ... 650 Hz
Pulse frequency	8 kHz (standard), 2 ... 16 kHz (in steps of 2 kHz)
Frequency bands that can be skipped	1, programmable
Efficiency	$\geq 96\%$
Interfaces	<ul style="list-style-type: none"> • Connection to PROFIBUS via IM151 interface module • Connection to PROFINET via IM151-3PN interface module • Integration of PLC functionality through IM151 CPU and IM151-7 F CPU interface modules • RS232 interface with USS protocol for commissioning on the PC with the STARTER commissioning software • Slot for an optional Micro Memory Card for uploading or downloading parameter settings • PTC/KTY84 interface for motor monitoring • Speed sensor interface (Sub-D connector) for unipolar HTL incremental encoder • Activation of the integrated safety functions over PROFlsafe (using the PM-D F PROFlsafe Power Module) or terminals (using the Safety Local Power Module PM-D F X1)
Standards conformance	UL, cUL, CE and c-tick, Low-Voltage Directive 73/23/EEC, EMC Directive 89/336/EEC
Functional safety	<p>Closed-loop control module with integral safety functions to Category 3 of EN 954-1 and SIL 2 of IEC 61508:</p> <ul style="list-style-type: none"> • Safety torque off • Safely limited speed • Safe stop 1 <p>The safety functions "Safely limited speed" and "Safe stop 1" are certified for encoderless asynchronous motors. These safety functions are not approved for pull-through loads as in the case of lifting gear and winders</p>
Degree of protection	IP20



SIMATIC ET 200S FC
Control Units



SIMATIC ET 200S FC
Power Modules

Appendix

Overview of frequency inverters/converters for SIMATIC ET 200 distributed I/O (continued)

Frequency inverters are available for the SIMATIC ET 200 distributed I/O that are fully system-integrated modules. Inverters are available for the finely modular SIMATIC ET 200S FC system to the IP20 degree of protection as well as for the cabinet-free SIMATIC ET 200pro FC system to the IP65 degree of protection.

With a broad range of possibilities, the frequency inverters expand the functional scope of the modular modules that are available in both systems (e.g. inputs and outputs, technology modules, direct and soft starters). With suitable interface modules, connection to PROFIBUS and PROFINET is possible via the ET 200

system bus as well as integration of PLC functionality into the system. Fail-safe frequency inverter functions can be activated locally or via PRO-FIsafe.

An overview of the features of the SIMATIC ET 200pro FC frequency inverter series is given in the table below.

The complete product spectrum including ordering data, technical data and explanations can be found in Catalog IK PI "Industrial Communication for Automation and Drives" (SIMATIC ET 200pro FC will be available soon) and on the Internet at

<http://www.siemens.com/et200pro-fc>

SIMATIC ET 200pro FC	
Main features	<ul style="list-style-type: none"> • Complete embedding of a frequency inverter into a distributed I/O system to IP65 degree of protection • Easy assembly and low susceptibility to errors thanks to self-assembling energy and communications bus • Fast replacement of the frequency inverter during servicing without interruption of the bus communication to other modules within the SIMATIC ET 200pro FC • Frequency control (V/f), vector control without encoders • Line-commutated regenerative feedback by power electronics of the latest generation • Frequency inverter variant with integrated, autonomous, fail-safe functions without the need for complex external wiring
Rated outputs	1.1 kW (at 0 ... 55 °C ambient temperature) 1.5 kW (at 0 ... 45 °C ambient temperature)
Input voltage	3 AC 380 ... 480 V ±10%
Overall width	155 mm
Mains frequency	47 ... 63 Hz
Overload capability	<ul style="list-style-type: none"> • Overload current 1.5 × rated output current (i.e. 150% overload) over 60 s, cycle time 300 s • Overload current 2 × rated output current (i.e. 200% overload) over 3 s, cycle time 300 s
Output frequency	0 ... 650 Hz
Pulse frequency	4 kHz (standard) 2 ... 16 kHz (in steps of 2 kHz)
Frequency bands that can be skipped	1, programmable
Efficiency	≥ 96%
Interfaces	<ul style="list-style-type: none"> • Connection to PROFIBUS through IM154-1 and IM154-2 interface modules • Available soon connection to PROFINET over IM154-4PN interface modules and connection to IM154-8 CPU interface modules • Optical interface with USS protocol for fiber-optic RS232 connecting cable • Control signal for 180 V DC electromagnetic motor brake • Slot for an optional memory card (MMC) for uploading or downloading parameter settings • PTC/KTY84 interface for motor temperature monitoring • Activation of the integrated safety functions through the Safety Local Isolator Module F RSM or through F-Switch PROFIsafe
Standards conformance	UL, cUL, CE, Low-Voltage Directive 73/23/EEC, EMC Directive 89/336/EEC
Functional safety	Variant with integral safety functions to Category 3 of EN 954-1 and SIL 2 of IEC 61508: <ul style="list-style-type: none"> • Safety torque off • Safely limited speed • Safe stop 1 The safety functions "Safely limited speed" and "Safe stop 1" are certified for encoderless asynchronous motors. These safety functions are not approved for pull-through loads as in the case of lifting gear and winders
Degree of protection	IP20



SIMATIC ET 200pro FC
Standard frequency inverter



SIMATIC ET 200pro FC Failsafe
Frequency inverter with integrated safety functions

Overview of SINAMICS G110 inverter chassis units

The SINAMICS G110 inverter chassis unit is a versatile drive. The table provides an overview of the features of this

product. The complete range of products together with ordering data, technical data and explanations are indicated

in the D 11.1 Catalog "SINAMICS G110/SINAMICS G120 Inverter Chassis Units and SINAMICS G120D

Distributed Frequency Inverters" and in the Internet under: <http://www.siemens.com/sinamics-g110>

SINAMICS G110	
Main features	As " a versatile drive for small outputs ", the frequency inverter of the SINAMICS G110 inverter chassis units can be used for a wide range of industrial drive applications with variable speeds. The especially compact SINAMICS G110 inverter works with voltage-frequency control (V/f) and is the ideal frequency inverter in the lower output and performance range of the SINAMICS family of products. The inverter is available in three frames for connection to single-phase power supply systems.
Electrical data	
Supply voltages, output range	1 AC 200 V ... 240 V, $\pm 10\%$; 0.12 kW ... 3.0 kW
Network types	IT, TN, TT
Mains frequency	50/60 Hz
Output frequency	0 Hz ... 650 Hz
Control method	V/f control, linear ($M \sim n$) V/f control, quadratic ($M \sim n^2$) V/f control, programmable
Fixed frequencies	3, programmable
Skip frequency ranges	1, programmable
Digital inputs	3 programmable digital inputs 24 V DC
Analog input (for the analog version)	1 analog input for setpoints from 0 V to 10 V, scalable or usable as 4th digital input
Digital output	1 digital output 24 V DC
Communication interface (for USS version)	RS485 serial interface for operation with USS protocol
Software functions	<ul style="list-style-type: none"> • Automatic restart after interruption of operation due to supply failure • Jerk-free connection of inverter to rotating motor • Programmable ramp-up/ramp-down times • Ramp rounding
Functions	
Protection functions	<ul style="list-style-type: none"> • Undervoltage • Overvoltage • Earth fault • Short-circuit • Stall prevention • I^2t motor thermal protection • Inverter overtemperature • Motor overtemperature
Connectable motors	Asynchronous motors
Mechanical data	
Degree of protection	IP20
Type of cooling for ≤ 0.75 kW inverters > 0.75 kW inverters	Ribbed heat sink with convection cooling; version with flat heat sink also available Internal air cooling (integrated fan)
Standards	
Standards complied with	CE, UL, cUL, c-tick



SINAMICS G110 inverter chassis units

Appendix

Overview of SINAMICS G120 inverter chassis units

The SINAMICS G120 inverter chassis unit is a modular drive. The table provides an overview of the features of this product. The complete range

of products together with ordering data, technical data and explanations are indicated in the D 11.1 Catalog "SINAMICS G110/SINAMICS

G120 Inverter Chassis Units and SINAMICS G120D Distributed Frequency Inverters" and in the Internet under:

<http://www.siemens.com/sinamics-g120>

SINAMICS G120	
Main features	As "a modular single drive for low and medium outputs" , the frequency inverter of the SINAMICS G120 inverter chassis units can be used for a wide range of industrial drive applications. The SINAMICS G120 frequency inverter distinguishes itself through its modular design (Power Module and Control Unit), and the globally unique integration of numerous innovative functions in safety technology and regenerative feedback into the line supply. There are extensive system components available in the range from 0.37 to 90 kW. This means that the drive units are suitable for a multitude of drive applications.
Electrical data	
Supply voltages, output range	3 AC 380 V ... 480 V, $\pm 10\%$; 0.37 kW ... 90 kW
Network types	IT, TN, TT
Mains frequency	47 ... 63 Hz
Output frequency	0 Hz ... 650 Hz
Control method	V/f control, linear ($M \sim n$) V/f control, quadratic ($M \sim n^2$) and parameterizable sensorless vector control, vector control with encoder (closed control loop) Torque control
Fixed frequencies	16, programmable
Digital inputs	up to 9 digital inputs, depending on the Control Unit 24 V DC
Analog input (for the analog version)	up to 2 analog inputs (0 V to 10 V)
Digital output	3 digital inputs
Communication interface	RS485/USS; PROFIBUS; PROFINET
Functions	
Software functions	<ul style="list-style-type: none"> • Programmable ramp-up times 0 ... 650 s, ramp rounding • Automatic restart after interruption of operation due to supply failure • Flying restart • Signals are locally pre-processed using free function blocks • 3 selectable motor data sets • High-quality internal PID controller for simple process control • Positioning ramp down • Kinetic buffering
Protection functions	<ul style="list-style-type: none"> • Motor temperature (PTC/KTY, P_t) • Power unit and load cycle monitoring • Overvoltage and undervoltage • Earth fault • Stall prevention • System protection functions
Safety Integrated Functions	STO, SS1, SLS, SBC
Connectable motors	Asynchronous motors
Mechanical data	
Degree of protection	IP20
Cooling method	Innovative cooling concept; the power electronics are cooled by means of heat sinks with an external fan; open-loop and closed-loop control electronics are cooled by convection
Standards	
Standards complied with	CE, UL, cUL, c-tick, Safety Integrated IEC 61508/SIL 2



SINAMICS G120 inverter chassis units

Overview of SINAMICS G120D distributed frequency inverter

The SINAMICS G120D frequency inverter is a modular drive. The table provides an overview of the features of this product. The complete range

of products together with ordering data, technical data and explanations are indicated in the D 11.1 Catalog "SINAMICS G110/SINAMICS

G120 Inverter Chassis Units and SINAMICS G120D Distributed Frequency Inverters" and in the Internet under:

<http://www.siemens.com/sinamics-g120d>

SINAMICS G120D	
Main features	"The modular drive for low and medium outputs" – the SINAMICS G120D distributed frequency inverter can be especially used for sophisticated conveyor applications in industry as for many other high-performance applications. The SINAMICS G120 frequency inverter distinguishes itself through its modular design (Power Module and Control Unit) as well as through its extremely flat type of construction, an identical drilling template for all outputs and a high degree of safety. It offers safety functions that are unique in its class. It helps to save significant amounts of energy as a result of its line-commutated regenerative feedback capability. It goes without saying that the frequency inverter is also capable of communications.
Electrical data	
Supply voltages, output range	3 AC 380 V ... 480 V, ±10%; 0.75 kW ... 7.5 kW
Network types	IT, TN, TT
Mains frequency	47 ... 63 Hz
Output frequency	0 Hz ... 650 Hz
Control method	V/f control, linear ($M \sim n$) V/f control, quadratic ($M \sim n^2$) and parameterizable sensorless vector control, vector control with encoder (closed control loop) Torque control
Fixed frequencies	16, programmable
Digital inputs	up to 6 digital inputs, depending on the Control Unit 24 V DC
Analog input (for the analog version)	up to 2 analog inputs (0 V to 10 V)
Digital output	3 digital inputs
Communication interface	PROFIBUS; PROFINET
Functions	
Software functions	<ul style="list-style-type: none"> • Programmable ramp-up times 0 ... 650 s, ramp rounding • Automatic restart after interruption of operation due to supply failure • Flying restart • Signals are locally pre-processed using free function blocks • 3 selectable motor data sets • High-quality internal PID controller for simple process control • Positioning ramp down • Kinetic buffering
Protection functions	<ul style="list-style-type: none"> • Motor temperature (PTC/KTY, R_t) • Power unit and load cycle monitoring • Overvoltage and undervoltage • Earth fault • Stall prevention • System protection functions
Safety Integrated Functions	STO, SS1, SLS
Connectable motors	Asynchronous motors
Mechanical data	
Degree of protection	IP65
Cooling method	Convection cooling, for higher outputs with fan
Standards	
Standards complied with	CE, UL, cUL, c-tick, Safety Integrated IEC 61508/SIL 2



SINAMICS G120D distributed frequency inverter

MICROMASTER 420/430/440

Appendix

Overview of IEC squirrel-cage motors

With an output range from 0.06 to 1250 kW, low-voltage motors are available for the widest range of requirements and applications that are harmonized and coordinated with the MICROMASTER and SINAMICS frequency inverters.

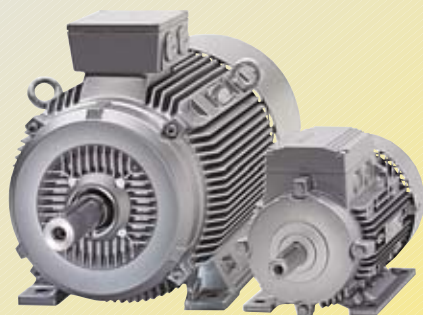
In addition to energy-saving motors and explosion-proof motors, there are also sector and customer-specific motors such as smoke extraction motors.

The table shows an overview of the technical features of these motors. You will find the available product range with ordering data, technical data and detailed explanations in Catalog D 81.1 "Low-Voltage

Motors – IEC Squirrel-Cage Motors – Frame Sizes 56 to 450" and

in the Internet under:
<http://www.siemens.com/motors>

Versions	IEC Squirrel-Cage Motors		
	Energy-saving motors		Smoke extraction motors
	Aluminum housing	Gray cast housing	Temp.-time classes F200/F300/F400
Rated power	0.06 ... 45 kW	0.75 ... 1250 kW	0.37 ... 200 kW
Frame sizes	56 M to 225	100 L to 450	80 M to 315 L
Type of construction	All common types of construction	All common types of construction	All common types of construction
Speed	750 ... 3000 rpm	750 ... 3000 rpm	1000 ... 3000 rpm
Rated torque	0.3 ... 292 Nm	9.9 ... 10300 Nm	2.5 ... 1546 Nm
Rated voltages	All commonly used voltages	All commonly used voltages	230VΔ/400 VY, 500 VΔ, 400VΔ/690 VY, 500 VY
Designation	EFF1, EFF2	EFF1, EFF2	EFF1, EFF2
Degree of protection	IP55	IP55	IP55
Housing	Aluminum	Gray iron	Aluminum Gray iron
Cooling type	Surface-cooled	Surface-cooled	Surface-cooled
Temperature class	155 (F) utilized to 130 (B) / 155 (F)	155 (F) utilized to 130 (B) / 155 (F)	155 (F) utilized to 130 (B)
Approvals	CE, CCC, UL, CSA	CE, CCC, UL, CSA	CE
Approvals for marine propulsion drives	Below deck use: BV, DNV, GL, LR	Below deck use: BV, DNV, GL, LR	No
Explosion protection (incl. temp. class)	Ex nA II T3 (Zone 2), Dust-ex (Zone 21, 22)	Ex nA II T3 (Zone 2), Dust-ex (Zone 21, 22)	No



Examples, energy-saving motors



Example, smoke extraction motors

Overview of IEC squirrel-cage motors

Versions	IEC Squirrel-Cage Motors			
	Explosion-proof motors			
	Type of protection "e"	Type of protection "d"	Type of protection "n"	Dust explosion protection
Rated power	0.12 ... 165 kW	0.25 ... 950 kW	0.09 ... 1000 kW	0.06 ... 1000 kW
Frame sizes	63 M to 315 L	71 M to 450	63 M to 450	Zone 21: 56 M to 315 L Zone 22: 56 M to 450
Type of construction	All common types of construction	All common types of construction	All common types of construction	All common types of construction
Speed	1000 ... 3000 rpm	750 ... 3000 rpm	750 ... 3000 rpm	750 ... 3000 rpm
Rated torque	0.61 ... 1300 Nm	1 ... 8579 Nm	1 ... 8090 Nm	0.3 ... 8090 Nm
Rated voltages	All commonly used voltages	All commonly used voltages	All commonly used voltages	All commonly used voltages
Designation	See Catalog D 81.1	See Catalog D 81.1	Analog energy-saving motors EFF1/EFF2	Analog energy-saving motors EFF1/EFF2
Degree of protection	IP55, IP56 (non-heavy-sea), IP65	IP55, IP56 (non-heavy-sea)	IP55, IP56 (non-heavy-sea), IP65	Zone 21: IP65 Zone 22: IP55
Housing	FS 63 ... 160 L Aluminum FS 100 L ... 315 L Gray iron	FS 71 M ... 315 L Gray iron FS 355 ... 450 Steel	FS 63 M ... 160L Aluminum FS 100 L ... 450 Gray iron	FS 63 M ... 225 M Aluminum FS 100 L ... 450 Gray iron
Cooling type	Surface-cooled	Surface-cooled	Surface-cooled	Surface-cooled
Temperature class	155 (F) utilized to 130 (B) / 155 (F)	155 (F) utilized to 130 (B) (line operation) 155 (F) utilized to 155 (F) (frequency inverter operation)	155 (F) utilized to 130 (B)	155 (F) utilized to 130 (B)
Approvals	CE, CCC, GOST, ATEX	CE, CCC, GOST, ATEX, NEPSI	CE, CCC, GOST, ATEX, NEPSI	CE, CCC, GOST, ATEX
Approvals for marine propulsion drives	Below deck use: BV, DNV, GL, LR	Below deck use: BV, DNV, GL, LR	Below deck use: BV, DNV, GL, LR	Below deck use: BV, DNV, GL, LR
Explosion protection (incl. temp. class)	II 2G Ex e II T1-T3	II 2G Ex de IIC T1-T4	II 3G Ex nA II T3	Zone 21: II 2D Ex tD A21 IP65 T125 °C Zone 22: II 3D Ex tD A22 IP55 T125 °C



Examples, explosion-proof motors

MICROMASTER 420/430/440

Appendix

Overview of IEC squirrel-cage motors – new generation 1LE1

Increasing energy costs have resulted in greater emphasis on the power consumption of drive systems. It is extremely important to utilize the full potential for minimization here to secure competitiveness today and in the future. This is the reason that already today,

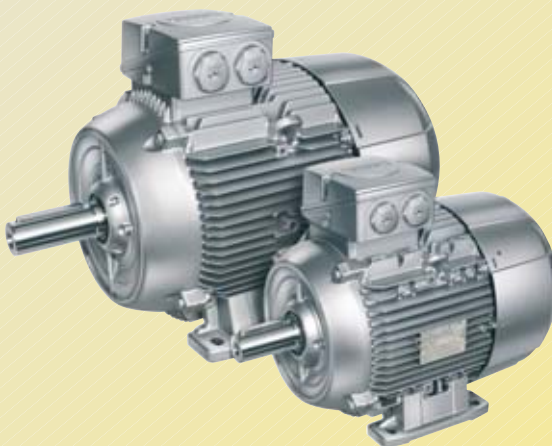
Siemens is developing a new generation of low-voltage motors. Innovative copper rotors create the best requisites for motors with high efficiencies. The new motors for EFF1 (High Efficiency) offer considerable energy savings and protect our environment.

The table shows an overview of the technical features of these motors. The presently available product range with ordering data, technical data and detailed explanations are provided in the new Catalog News D 81.1 N "Low-Voltage Motors – IEC Squirrel-Cage

Motors – New Generation 1LE1 – Frame Size 100 to 160" and

in the Internet under:
<http://www.siemens.com/motors>

IEC Squirrel-Cage Motors – new generation 1LE1	
Versions	Self-cooled energy-saving motors with: <ul style="list-style-type: none"> • Improved efficiency (EFF2) • High efficiency (EFF1) Self-cooled motors with increased output and: <ul style="list-style-type: none"> • Improved efficiency (EFF2) • High efficiency (EFF1) Forced-air-cooled motors without external fan and fan cover with: <ul style="list-style-type: none"> • Improved efficiency (EFF2) • High efficiency (EFF1)
Rated power	0.75 ... 22 kW
Frame sizes	100 L to 160 L
Type of construction	Without flange: IM B3, IM B6, IM B7, IM B8, IM V5 without protective cover, IM V6, IM V5 with protective cover With flange: IM B5, IM V1 without protective cover, IM V1 with protective cover, IM V3, IM B35 With standard flange: IM B14, IM V19, IM V18 without protective cover, IM V18 with protective cover, IM B34
Speed	750 ... 3000 rpm
Rated torque	9.9 ... 150 Nm
Rated voltages	All commonly used voltages
Designation	EU/CEMEP efficiency classification: EFF1: 2-, 4-pole, EFF2: 2-, 4-pole US Energy Policy Act EPACT: 2-, 4-, 6-pole (available soon)
Degree of protection	IP55 as standard
Housing	Aluminum
Cooling type	Self-cooled: Frame size 100 L to 160 L (IC 411), Forced-air cooled: Frame size 100 L to 160 L (IC 416)
Temperature class	Temperature class 155 (F), utilized to temperature class 130 (B)
Approvals	CE



Examples, IEC squirrel-cage motors – new generation 1LE1, aluminum housing

Overview of distributed drive solutions – MICROMASTER 411 and COMBIMASTER 411 inverters

The MICROMASTER 411 and COMBIMASTER 411 inverters from Siemens are available as distributed drive solutions. The table provides an over-

view of the features of these products. The complete range of products together with ordering data, technical data and explanations are indicat-

ed in the Catalog DA 51.3 MICROMASTER 411 and COMBIMASTER 411. The latest information on MICROMASTER 411 and

COMBIMASTER 411 is available in the Internet under: <http://www.siemens.com/combimaster>

	MICROMASTER 411	COMBIMASTER 411
Main features	"The distributed inverter" for a wide range of drive applications – for simple individual applications from pumps and fans to multiple conveyor-belt drives in networked control systems.	
Output range	0.37 kW ... 3 kW	
Voltage range	3 AC 380 V ... 480 V	
Frame sizes/ unit sizes	CS B CS C	71 ... 100 90/100
Types of construction		IM B3 IM B5 IM V1 (without protective cover) IM V1 (with protective cover) IM B14 (with normal flange) IM B14 (with special flange) IM B35
Degree of protection	IP65	IP55
Other technical features	<ul style="list-style-type: none"> • V/f characteristic • Multipoint characteristic (programmable V/f characteristic) • FCC (flux current control) • Internal PI controller • 3 digital inputs • 1 analog input • 1 relay output • Compound braking for controlled rapid braking • ECOFAST versions with plug-in connectors for power-supply, communication interface and motor connections in order to enable fast and problem-free information exchange in applications where time is a critical factor. The ECOFAST versions are completely compatible with the ECOFAST technology systems. 	



Examples MICROMASTER 411



Examples COMBIMASTER 411

Appendix

Overview of NEMA motors

For compliance with the local specifications of the NAFTA markets (USA, Canada and Mexico), we manufacture low-voltage motors acc. to the NEMA standard for a wide range of different application areas.

This includes motors designed in accordance with the US act, EPACT (specified minimum efficiency levels), as well as motors with NEMA premium efficiency levels: Our NEMA motor series provide the highest operating reliability and maximum service life.

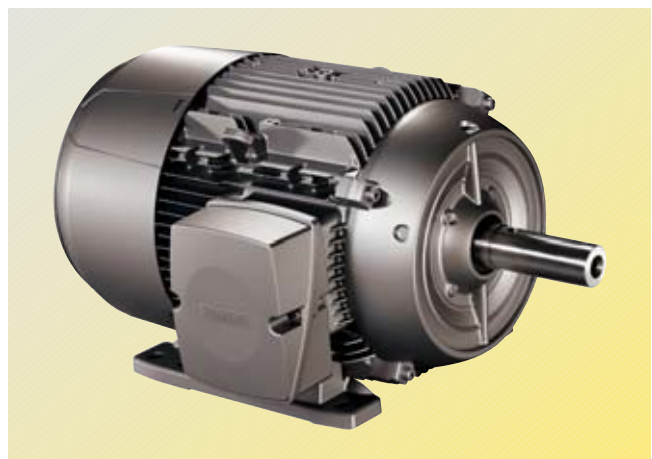
Designed and manufactured for rugged operation, our NEMA motors conquer even the harshest industrial conditions strictly in accordance with the ISO 9001 international quality standard; with maximum performance, reliability and efficiency.

You will find the complete range of products together with ordering data, technical data and explanations in Catalog D 81.2 U.S./Canada on the Internet at <http://www.sea.siemens.com/motors>

	NEMA motors (NEMA = National Electrical Manufacturers Association)
Frame size	NEMA frame size 56 ... 449
Output range	0.25 HP ... 500 HP
Number of poles	2/4/6/8
Voltages	3 AC 230/460/575 V
Frequency	60 Hz, 50 Hz on request
Type of construction	Foot-mounted, D flange, C flange, P flange
Casing	Cast-iron, aluminium or steel depending on the version
Cooling method	Surface-cooling or internal ventilation depending on the version
Temperature class	F used acc. to B
Type spectrum	General purpose motors <ul style="list-style-type: none"> • Legally specified minimum efficiency levels or NEMA premium efficiency levels • Standard motors for general industrial use • Aluminium or cast-iron case depending on the version Severe duty motors <ul style="list-style-type: none"> • Legally specified minimum efficiency levels or NEMA premium efficiency levels • Cast-iron case • Motors for use under extremely difficult environmental conditions Severe duty IEEE841 motors <ul style="list-style-type: none"> • Efficiency levels required by IEEE that exceed the EPACT act • Motors with increased requirements for use in the petrochemical industry (according to IEEE841) • Cast-iron case Explosion-proof motors <ul style="list-style-type: none"> • Efficiency levels better than or equal to EPACT • Multi label according to Division 1, Class I, Group D and Class II, Groups F&G • Single label according to Division 1, Class I, Groups C&D



Example of NEMA motor, Severe Duty SD100, cast-iron case



Example of NEMA motor, General Purpose GP10A, aluminium case

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By further specifying the remaining criteria you will find exactly the right contact partner with his/her respective expertise.

MICROMASTER 420/430/440

Appendix

A&D in the WWW



A detailed knowledge of the range of products and services available is essential when planning and configuring automation systems. It goes without saying that this information must always be fully up-to-date.

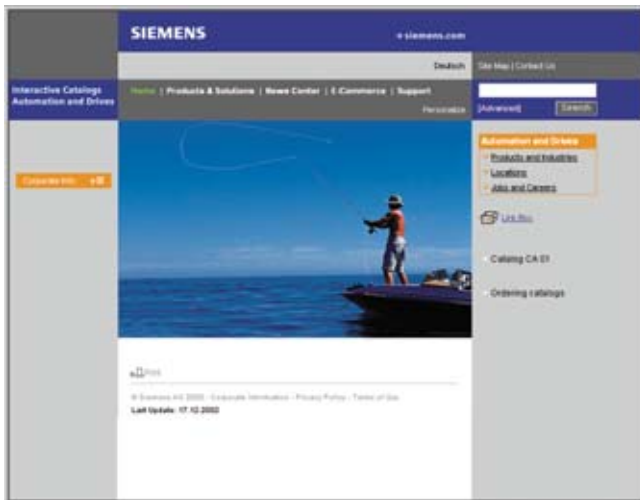
The Siemens Automation and Drives Group (A&D) has therefore built up a comprehensive range of information in the World Wide Web, which offers quick and easy access to all data required.

Under the address

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Information on the Offline Mall CA 01 can be found in the Internet under

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The delivery state for specific orders can be displayed for all shipped SINAMICS products.
<http://workplace.automation.siemens.com/sparesonweb>

¹⁾ For country-specific telephone numbers go to our Internet site at:
<http://www.siemens.com/automation/service&support>

MICROMASTER 420/430/440

Appendix

Subject index

MICROMASTER

	4..	420	430	440
	Page	Page	Page	Page
A				
AAOP (operator panel)	-	2/16	-	4/22
AOP (operator panel)	-	2/16	-	4/22
Applications	-	2/2	3/2	4/2
Assignment table for options	1/4	1/4	1/4	1/4
B				
BOP (operator panel)	-	2/16	-	4/22
BOP-2 (operator panel)	-	-	3/16	-
Brake resistor (option)	-	-	-	4/17
C				
CANopen module	-	2/16	3/16	4/22
CAOP (operator panel)	-	2/16	-	4/22
CE marking	A/4	A/4	A/4	A/4
Certificates	A/2	A/2	A/2	A/2
Chokes (options)	-	2/13	3/14	4/17
Circuit diagrams	-	2/4	3/4	4/4
Circuit-breaker (option)	-	2/14	3/14	4/18
COMBIMASTER 411 (overview)	A/17	A/17	A/17	A/17
Communications modules	-	2/16	3/16	4/22
Compliance with standards	A/4	A/4	A/4	A/4
Conditions of sale and delivery	A/24	A/24	A/24	A/24
D				
Demonstration case	A/7	A/7	A/7	A/7
Derating data	-	2/7	3/7	4/7
Description (inverter)	-	2/2	3/2	4/2
Description (options)	-	2/9	3/10	4/12
Design	-	2/2	3/2	4/2
DeviceNet module (option)	-	2/16	3/16	4/22
Dimension drawings	-	2/18	3/19	4/26
Docu pack	-	2/17	3/18	4/25
Documentation	-	2/17	3/18	4/25
Drive ES	A/6	A/6	A/6	A/6
Drive ES software	A/6	A/6	A/6	A/6
DriveMonitor	-	2/15	3/16	4/22
E				
Electromagnetic compatibility	A/5	A/5	A/5	A/5
EMC filter (option)	-	2/12	3/14	4/16
Environment, resources and recycling	A/2	A/2	A/2	A/2
Export regulations	A/24	A/24	A/24	A/24
F				
Features	-	2/3	3/3	4/3
Filter (option)	-	2/12	3/14	4/16
Fuses (options)	-	2/14	3/14	4/18
G				
General circuit diagram	-	2/4	3/4	4/4
Getting Started Guide	-	2/17	3/18	4/25
I				
Installation altitude (derating)	-	2/7	3/8	4/8
Integration with Drive ES	A/6	A/6	A/6	A/6
International standards	-	2/2	3/2	4/2
Internet (online services)	A/20	A/20	A/20	A/20
L				
LC filter	-	2/13	3/14	4/17
Line commutating chokes (option)	-	2/13	3/14	4/16

MICROMASTER

	4..	420	430	440
	Page	Page	Page	Page
M				
Main characteristics	-	2/2	3/2	4/2
Mechanical features	-	2/3	3/3	4/3
MICROMASTER 411 (overview)	A/17	A/17	A/17	A/17
Motors (overview)	A/14	A/14	A/14	A/14
N				
NEMA motors (overview)	A/18	A/18	A/18	A/18
Notes on ordering	A/23	A/23	A/23	A/23
O				
Online services	A/20	A/20	A/20	A/20
Operating instructions	-	2/17	3/18	4/25
Operating temperature (derating)	-	2/7	3/7	4/8
Operator panels	1/4	2/16	3/16	4/22
Options	1/4	2/9	3/10	4/12
Ordering data (inverter)	-	2/8	3/9	4/9
Ordering data (options)	-	2/12	3/14	4/16
Output chokes (option)	-	2/13	3/14	4/17
Overview	1/2	1/2	1/3	1/3
P				
Parameter list	-	2/17	3/18	4/25
Performance features	-	2/3	3/3	4/3
PROFIBUS module (option)	-	2/16	3/16	4/22
Protection features	-	2/3	3/3	4/3
Pulse encoder evaluation module (option)	-	-	-	4/22
Pulse frequency (derating)	-	2/7	3/7	4/7
S				
Selection and ordering data (inverter)	-	2/8	3/9	4/9
Selection and ordering data (options)	-	2/11	3/14	4/16
Selection guide	1/2	1/2	1/3	1/3
Service and support	A/21	A/21	A/21	A/21
SIDEMO (demonstration case system)	A/7	A/7	A/7	A/7
Siemens contacts worldwide	A/19	A/19	A/19	A/19
Sinusoidal filter	-	-	3/14	4/17
STARTER	-	2/16	3/16	4/22
Start-up tools	-	2/15	3/16	4/22
Support	A/21	A/21	A/21	A/21
T				
Technical data (inverter)	-	2/6	3/6	4/6
Technical data (options)	-	2/10	3/10	4/12
Terminal connection diagram	-	2/5	3/5	4/5
Terminal connection plates (option)	-	2/14	3/14	4/18
Training	A/8	A/8	A/8	A/8
U				
UL listing	A/5	A/5	A/5	A/5
V				
Variant dependent options	-	2/12	3/14	4/16
Variant independent options	-	2/16	3/16	4/22

Order No. index

Notes on ordering

Versions/variants

The last digit of the complete Order No. for the inverters represents the release version.

When ordering, a different digit from the one specified may be present as a result of further technical development.

MICROMASTER

	420	430	440
	Page	Page	Page
3NA3...	2/14	3/14, 3/15	4/18, 4/20
3NE1...	-	3/14, 3/15	4/18, 4/20
3RV10..	2/14	3/14, 3/15	4/18, 4/20
3VL....	-	3/14, 3/15	4/18, 4/20
6AG1062-1AA..	A/7	-	A/7
6GK1500-0FC00	2/16	3/16	4/22
6SE6400-0AP00-0AA1	2/16	-	4/22
6SE6400-0AP00-0AB0	2/16	-	4/22
6SE6400-0AP00-0CA0	2/16	-	4/22
6SE6400-0BE00-0AA0	-	3/16	-
6SE6400-0BP00-0AA0	2/16	-	4/22
6SE6400-0EN00-0AA0	-	-	4/22
6SE6400-0GP00-0.A0	2/14	3/14	4/18, 4/19
6SE6400-0MD00-0AA0	2/16	-	4/22
6SE6400-0P.00-0AA0	2/16	3/16	4/22
6SE6400-1CB00-0AA0	2/16	3/16	4/22
6SE6400-1DN00-0AA0	2/16	3/16	4/22
6SE6400-1P.00-0AA0	2/16	3/16	4/22
6SE6400-2FA0.	2/12	-	4/16
6SE6400-2FB0.	2/12	-	4/16
6SE6400-2FL0.	2/13	-	4/16
6SE6400-2FS0.	2/12	3/15	4/19
6SE6400-3CC..	2/13	3/14, 3/15	4/16, 4/19
6SE6400-3TC..	2/13	3/14, 3/15	4/17, 4/19
6SE6400-3TD..	2/13	3/14, 3/15	4/17, 4/19
6SE6400-4B...	-	-	4/17, 4/19
6SE6400-5....	2/17	3/18	4/25
6SE6420-2AB..	2/8	-	-
6SE6420-2AC..	2/8	-	-
6SE6420-2AD..	2/8	-	-
6SE6420-2UC..	2/8	-	-
6SE6420-2UD..	2/8	-	-
6SE6430-2AD..	-	3/9	-
6SE6430-2UD..	-	3/9	-
6SE6440-2AB..	-	-	4/11
6SE6440-2AC..	-	-	4/11
6SE6440-2AD..	-	-	4/11
6SE6440-2UC..	-	-	4/9
6SE6440-2UD..	-	-	4/9
6SE6440-2UE..	-	-	4/10
6SL3000-0BE3.	-	3/14	4/16
6SL3000-0CE3.	-	3/14	4/17
6SL3000-2BE..	-	3/14	4/17
6SL3000-2CE..	-	3/14	4/16
6SL3072-0AA0.	2/16	3/16	4/22
6SW1700-0J...	A/6	A/6	A/6
6SW1700-5J...	A/6	A/6	A/6
6SW1700-6J...	A/6	A/6	A/6
6ZB5310-0K...	A/24	A/24	A/24

Appendix

Terms and Conditions of Sale and Delivery

By using this catalog you can acquire hardware and software products described therein from Siemens AG subject to the following terms. Please note! The scope, the quality and the conditions for supplies and services, including software products, by any Siemens entity having a registered office outside of Germany, shall be subject exclusively to the General Terms and Conditions of the respective Siemens entity. The following terms apply exclusively for orders placed with Siemens AG.

For customers with a seat or registered office in Germany

The "General Terms of Payment" as well as the "General Conditions for the Supply of Products and Services of the Electrical and Electronics Industry" shall apply.

For software products, the "General License Conditions for Software Products for Automation and Drives for Customers with a Seat or registered Office in Germany" shall apply.

For customers with a seat or registered office outside of Germany

The "General Terms of Payment" as well as the "General Conditions for Supplies of Siemens Automation and Drives for Customers with a Seat or registered Office outside of Germany" shall apply.

For software products, the "General License Conditions for Software Products for Automation and Drives for Customers with a Seat or registered Office outside of Germany" shall apply.

General

The dimensions are in mm. In Germany, according to the German law on units in measuring technology, data in inches only apply to devices for export.

Illustrations are not binding.

Insofar as there are no remarks on the corresponding pages, - especially with regard to data, dimensions and weights given - these are subject to change without prior notice.

The prices are in € (Euro) ex works, exclusive packaging.

The sales tax (value added tax) is not included in the prices. It shall be debited separately at the respective rate according to the applicable legal regulations.

Prices are subject to change without prior notice. We will debit the prices valid at the time of delivery.

Surcharges will be added to the prices of products that contain silver, copper, aluminum, lead and/or gold if the respective basic official prices for these metals are exceeded. These surcharges will be determined based on the official price and the metal factor of the respective product.

The surcharge will be calculated on the basis of the official price on the day prior to receipt of the order or prior to the release order.

The metal factor determines the official price as of which the metal surcharges are charged and the calculation method used. The metal factor, provided it is relevant, is included with the price information of the respective products.

An exact explanation of the metal factor and the text of the Comprehensive Terms and Conditions of Sale and Delivery are available free of charge from your local Siemens business office under the following Order Nos.:

- 6ZB5310-0KR30-0BA1
(for customers based in Germany)
- 6ZB5310-0KS53-0BA1
(for customers based outside Germany)

or download them from the Internet

<http://www.siemens.com/automation/mall>

(Germany: A&D Mall Online-Help System)

Export regulations

The products listed in this catalog may be subject to European / German and/or US export regulations.

Therefore, any export requiring a license is subject to approval by the competent authorities.

According to current provisions, the following export regulations must be observed with respect to the products featured in this catalog:

AL	<p>Number of the <u>German Export List</u></p> <p>Products marked other than "N" require an export license.</p> <p>In the case of software products, the export designations of the relevant data medium must also be generally adhered to.</p> <p>Goods labeled with an <u>"AL" not equal to "N"</u> are subject to a European or German export authorization when being exported out of the EU.</p>
ECCN	<p><u>Export Control Classification Number</u></p> <p>Products marked other than "N" are subject to a reexport license to specific countries.</p> <p>In the case of software products, the export designations of the relevant data medium must also be generally adhered to.</p> <p>Goods labeled with an <u>"ECCN" not equal to "N"</u> are subject to a US re-export authorization.</p>

Even without a label or with an "AL: N" or "ECCN: N", authorization may be required due to the final destination and purpose for which the goods are to be used.

The deciding factors are the AL or ECCN export authorization indicated on order confirmations, delivery notes and invoices.

Errors excepted and subject to change without prior notice.

A&D/VuL_ohne MZ/En 05.09.06

Catalogs of the Automation and Drives Group (A&D)

Further information can be obtained from our branch offices listed in the appendix or at www.siemens.com/automation/partner

Automation and Drives		<i>Catalog</i>	
Interactive catalog on CD-ROM and on DVD			
• The Offline Mall of Automation and Drives	CA 01		
Automation Systems for Machine Tools			
SINUMERIK & SIMODRIVE	NC 60		
SINUMERIK & SINAMICS	NC 61		
Drive Systems			
<u>Variable-Speed Drives</u>			
SINAMICS G110/SINAMICS G120	D 11.1		
Inverter Chassis Units			
SINAMICS G120D			
Distributed Frequency Inverters			
SINAMICS G130 Drive Converter Chassis Units, SINAMICS G150 Drive Converter Cabinet Units	D 11		
SINAMICS GM150/SINAMICS SM150	D 12		
Medium-Voltage Converters			
SINAMICS S120 Drive Converter Systems	D 21.1		
SINAMICS S150 Drive Converter Cabinet Units	D 21.3		
Asynchronous Motors Standardline	D 86.1		
Synchronous Motors with Permanent-Magnet Technology, HT-direct	D 86.2		
DC Motors	DA 12		
SIMOREG DC MASTER 6RA70 Digital Chassis Converters	DA 21.1		
SIMOREG K 6RA22 Analog Chassis Converters	DA 21.2		
SIMOREG DC MASTER 6RM70 Digital Converter Cabinet Units	DA 22		
SIMOVERT PM Modular Converter Systems	DA 45		
SIEMOSYN Motors	DA 48		
MICROMASTER 410/420/430/440 Inverters	DA 51.2		
MICROMASTER 411/COMBIMASTER 411	DA 51.3		
SIMOVERT MASTERDRIVES Vector Control	DA 65.10		
SIMOVERT MASTERDRIVES Motion Control	DA 65.11		
Synchronous and asynchronous servomotors for SIMOVERT MASTERDRIVES	DA 65.3		
SIMODRIVE 611 universal and POSMO	DA 65.4		
<u>Low-Voltage Three-Phase-Motors</u>			
IEC Squirrel-Cage Motors	D 81.1		
<u>Automation Systems for Machine Tools SIMODRIVE</u>			
• Main Spindle/Feed Motors			
• Converter Systems SIMODRIVE 611/POSMO			
<u>Automation Systems for Machine Tools SINAMICS</u>			
• Main Spindle/Feed Motors			
• Drive System SINAMICS S120			
<u>Drive and Control Components for Hoisting Equipment</u>			
	HE 1		
Electrical Installation Technology			
<i>PDF: ALPHA Small Distribution Boards and Distribution Boards, Terminal Blocks</i>	ETA 1		
<i>PDF: ALPHA 8HP Molded-Plastic Distribution System</i>	ETA 3		
<i>PDF: BETA Low-Voltage Circuit Protection</i>	ET B1		
<i>PDF: DELTA Switches and Socket Outlets</i>	ET D1		
GAMMA Building Controls	ET G1		
Human Machine Interface Systems SIMATIC HMI			
	ST 80		
Industrial Communication for Automation and Drives		<i>Catalog</i>	
		IK PI	
Low-Voltage			
Controls and Distribution – SIRIUS, SENTRON, SIVACON		LV 1	
Controls and Distribution – Technical Information		LV 1 T	
SIRIUS, SENTRON, SIVACON			
SIDAC Reactors and Filters		LV 60	
SIVENT Fans		LV 65	
SIVACON 8PS Busbar Trunking Systems		LV 70	
Motion Control System SIMOTION			PM 10
Process Instrumentation and Analytics			
Field Instruments for Process Automation		FI 01	
Measuring Instruments for Pressure, Differential Pressure, Flow, Level and Temperature, Positioners and Liquid Meters			
<i>PDF: Indicators for panel mounting</i>		MP 12	
SIREC Recorders and Accessories		MP 20	
SIPART, Controllers and Software		MP 31	
SIWAREX Weighing Systems		WT 01	
Continuous Weighing and Process Protection		WT 02	
Process Analytical Instruments		PA 01	
<i>PDF: Process Analytics, Components for the System Integration</i>		PA 11	
SIMATIC Industrial Automation Systems			
SIMATIC PCS Process Control System		ST 45	
Products for Totally Integrated Automation and Micro Automation		ST 70	
SIMATIC PCS 7 Process Control System		ST PCS 7	
Add-ons for the SIMATIC PCS 7 Process Control System		ST PCS 7.1	
Migration solutions with the SIMATIC PCS 7 Process Control System		ST PCS 7.2	
pc-based Automation		ST PC	
SIMATIC Control Systems		ST DA	
SIMATIC Sensors			
Sensors for Factory Automation		FS 10	
Systems Engineering			
Power supplies SITOP power		KT 10.1	
System cabling SIMATIC TOP connect		KT 10.2	
System Solutions			
Applications and Products for Industry are part of the interactive catalog CA 01			
TELEPERM M Process Control System			
<i>PDF: AS 488/TM automation systems</i>		PLT 112	

www.siemens.com/micromaster

Siemens AG

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Standard Drives
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Germany

www.siemens.com/automation

The information provided in this catalog contains descriptions or characteristics of performance which in case of actual use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract. Availability and technical specifications are subject to change without notice.

All product designations may be trademarks or product names of Siemens AG or supplier companies whose use by third parties for their own purposes could violate the rights of the owners.

Order No. E86060-K5151-A121-A6-7600

ANEXO II

DataSheet Motor Trifásico

SIEMENS



Datenblatt für Drehstrom-Käfigläufermotoren

Data sheet for three-phase Squirrel-Cage-Motors

MLFB-Bestelldaten 1LA7096-4AA10-Z
MLFB-Ordering data: G26+K09

Kunden-Auftrags-Nr. / Client order no.:
Siemens-Auftrags-Nr. / Order no.:
Angebots-Nr. / Offer no.:
Bemerkung / Remarks:

ohne (Standard)
without (standard)

Item-Nr. / Item no.:
Komm.-Nr. / Consignment no.:
Projekt / Project:

Elektrische Daten / Electrical data:

Bemessungsspannung Rated voltage	(1) 230 VD/400 VY, 50 Hz, 460 VY, 60 Hz (1) 230 VD/400 VY, 50 Hz, 460 VY, 60 Hz					
Frequenz Frequency	50 Hz		60 Hz			
Bemessungsleistung Rated power	1.50 kW		1.75 kW			
Bemessungsdrehzahl Rated speed	1420 1/ min		1720 1/ min			
Bemessungsmoment Rated torque	10.1 Nm		9.7 Nm			
Bemessungsstrom (IE) Rated current (IE)	VD	VY	VY			
	6.00 A	3.45 A	3.30 A			
Anzugs-/ Bemessungsstrom Starting / rated current	5.3		5.6			
Kipp-/ Bemessungsmoment Breakdown / rated torque	2.6		2.6			
Anzugs-/Bemessungsmoment Starting / rated torque	2.4		2.4			
	4/4	3/4	2/4	4/4	3/4	2/4
Wirkungsgrad % Efficiency %	77.2%	77.7%	74.2%	81.5%	81.5%	80.5%
Leistungsfaktor Power factor	0.81	0.76	0.66	0.82	0.77	0.67
Wirkungsgradklasse / Efficiency	IE1		IE1			

Mechanische Daten / Mechanical data:

Schalldruckpegel (LpFA) 50Hz/60Hz (Last) Sound pressure level 50Hz/60Hz (load)	48 dB(A)	52 dB(A)
Trägheitsmoment Moment of inertia	0.0033 kg*m²	
Lager AS Bearing DE	6205 2ZC3	
Lager BS Bearing NDE	6004 2ZC3	
Art der Lagerung Type of bearing	Schwimmende Lagerung mit Anstellung AS (Standard)	
Kondenswasserlöcher Condensate drainage holes	Nein No	
Nachschmiereinrichtung Regreasing device	Nein No	
Schmiermittel Lubricants	Esso Unirex N3	
Fettgebrauchsdauer/Nachschmierintervall Grease lifetime/Relubrication interval	40000 h	
Fettmenge Nachschmierung Quantity of grease for relubrication	null g	
Äußere Erdungsklemme External earthing terminal	Nein No	
Anstrich Coating	Sonderanstrich RAL7030 steingrau Special paint finish RAL 7030 stone gray	

Umgebungsbedingungen / Environmental

Umgebungstemperatur Ambient temperature	-20 °C - +40 °C
Höhe über Meeresspiegel Altitude above sea level	1000 m
Normen und Vorschriften Standards and specifications	IEC, DIN, ISO, VDE, EN

Allgemeine Daten / General data:

Baugröße Frame size	090 L
Bauform der drehenden elektrischen Weight in kg, without optional accessories	(0) IM B3 / B6 / B7 / B8 / V5 ohne Schutzdach
Gewicht in kg, ohne optionale Anbauten Weight in kg, without optional accessories	15.60 kg
Gehäusematerial Frame material	Aluminium Aluminum
Schutzart Degree of protection	IP 55
Kühlart, TEFC, Method of cooling, TEFC	
Vibrationsklasse Vibration class	A (Standard)
Isolation Insulation	155(F) nach 130(B) 155(F) to 130(B)
Betriebsart Duty type	S1 - Dauerbetrieb S1 - continuous duty
Drehrichtung Direction of rotation	bidirektional Bi-directional

Anschlusskasten / Terminal box:

Klemmenkastenmaterial Material of terminal box	
Klemmenkastentyp Type of terminal box	gk 127
Gewinde Kontaktschraube Contact screw thread	
Max. Leiterquerschnitt Max. cross-sectional area	
Kabeldurchmesser von ... bis ... Cable diameter from ... to ...	
Kabeleinführung Cable entry	
Kabelverschraubung Cable gland	

Sonderausführung / Special design:

G26	Anbau Bremse Mounting a brake
K09	Anschlusskasten seitlich rechts Terminal box mounted on the right side

ANEXO III

Desenhos Técnicos

TRIBÓMETRO BLOCO-DISCO

(Guia Desenhos técnicos)

Desenho	Nº Desenho	Obs.
<u>Lista de peças</u>		
<i>1.Desenho conjunto/explodida:</i>		
Tribómetro	1.1	Equipamento montado
Configuração Bloco-Disco	1.2	Parte estrutural e funcional bloco-disco
Estrutura	1.3	Placas, veio, rolamentos...
Sistema de aplicação de carga	1.4	Parte estrutural e funcional aplicação de carga
<i>2.Desenhos definição:</i>		
Placa Inferior	2.1	
Placa Vertical	2.2	
Placa Superior	2.3	
Tampa Rolamento	2.4	
Veio Principal	2.5	
Suporte Amostra	2.6	
Veio Amostra	2.7	
Suporte Barra	2.8	
Veio Barra	2.9	
Barra	2.10	Barra com relação de força de 1:4
Amostra-Disco	2.11	Componentes de teste

4

3

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1

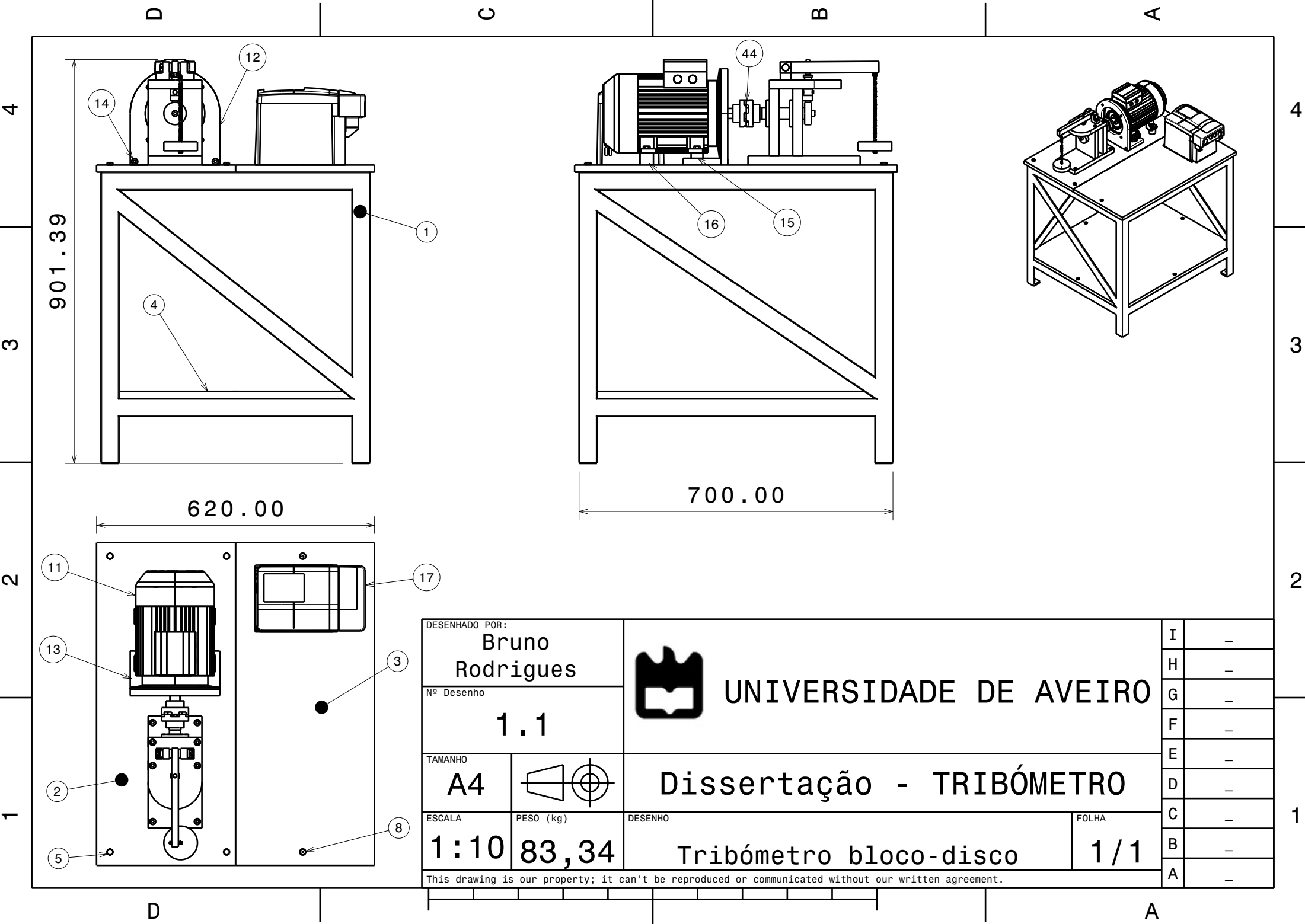
<u>LISTA DE PEÇAS DO TRIBÓMETRO</u>	
Nº Ref	DESIGNAÇÃO
1	ESTRUTURA MESA
2	CHAPA METÁLICA
3	PLACA MADEIRA SUPERIOR
4	PLACA MADEIRA INFERIOR
5	PARAFUSO CABEÇA HEXAGONAL ISO 4014 - M8x40
6	ANILHA PLANA ISO 7089 - 8x16
7	PORCA HEXAGONAL ISO 4032 - M8
8	PARAFUSO DE CABEÇA CILÍNDRICA COM OCO HEXAGONAL ISO 10642 - M6x40
9	ANILHA PLANA ISO 7089 - 6x12
10	PORCA HEXAGONAL ISO 4032 - M6
11	MOTOR TRIFÁSICO CA
12	SUORTE MOTOR FRONTAL
13	SUORTE MOTOR INFERIOR
14	PARAFUSO DE CABEÇA CILÍNDRICA COM OCO HEXAGONAL ISO 4762 - M8x20
15	CALÇO MOTOR FRONTAL
16	CALÇO MOTOR TRASEIRO
17	VARIADOR DE FREQUÊNCIA
18	PLACA INFERIOR
19	PLACA VERTICAL
20	PARAFUSO DE CABEÇA CILÍNDRICA COM OCO HEXAGONAL ISO 4762 - M8x35
21	JUNTA TOROIDAL 26x35x7 - ISO 9222
22	ROLAMENTO SKF - 6205
23	TAMPA ROLAMENTO
24	PARAFUSO DE CABEÇA CILÍNDRICA COM OCO HEXAGONAL ISO 4762 - M4x8
25	PLACA SUPERIOR
26	PINO CILÍNDRICO EN ISO 8734 - 6x28 - St
27	SUORTE BARRA
28	PARAFUSO DE CABEÇA CILÍNDRICA COM OCO HEXAGONAL ISO 4762 - M6x20
29	BARRA
30	VEIO BARRA
31	CASQUILHO
32	PINO CILÍNDRICO EN ISO 8734 - 4x20 - St
33	VEIO PRINCIPAL
34	DISCO
35	VEIO AMOSTRA
36	SUORTE AMOSTRA
37	PINO CILÍNDRICO COM CABEÇA
38	PINO CARGA
39	AMOSTRA
40	VARÃO ROSCADO M5
41	ANILHA PLANA ISO 7089 - 5x10
42	PORCA HEXAGONAL ISO 4032 - M5
43	PESO CALIBRADO
44	ACOPLADOR

D

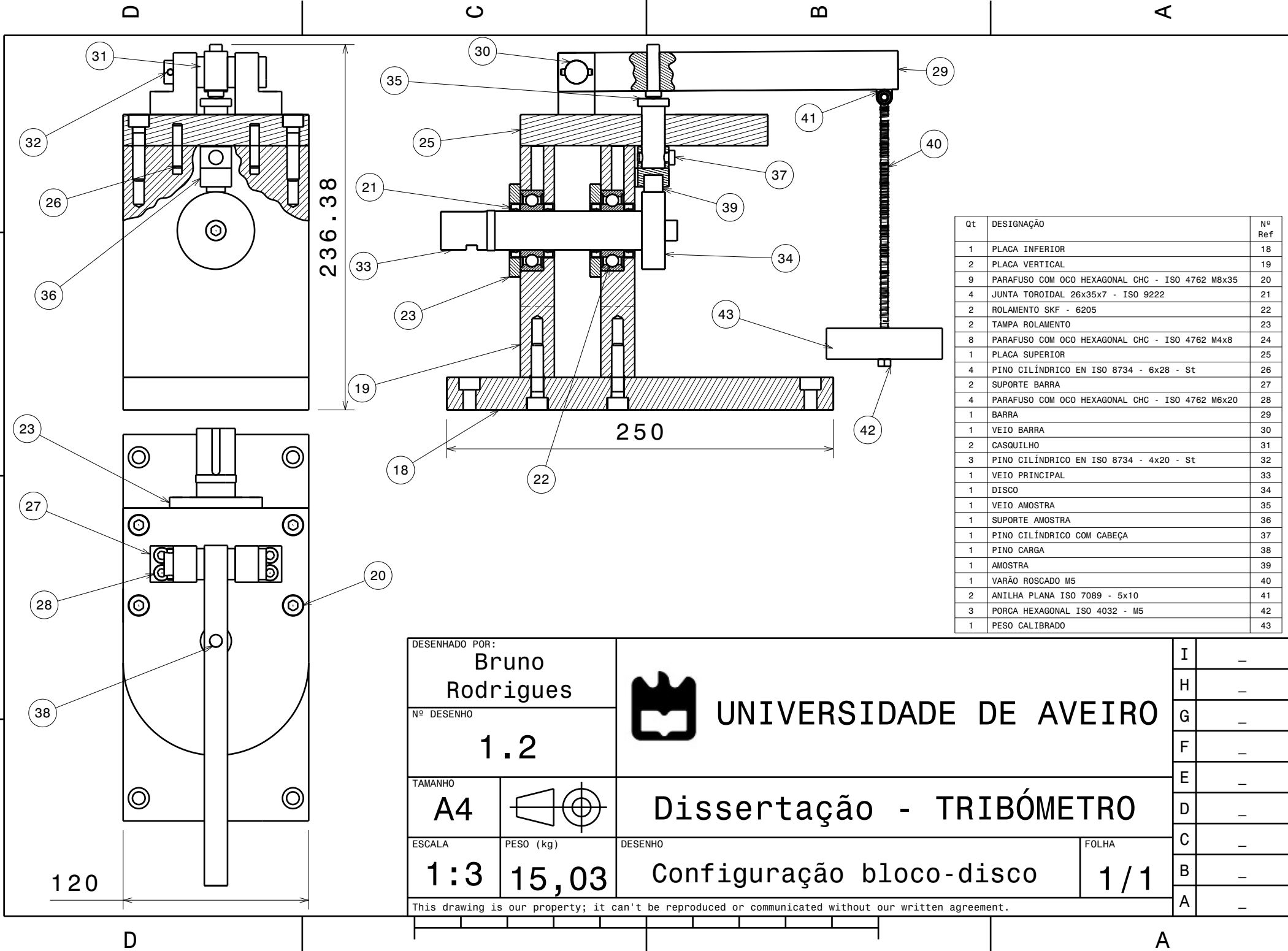
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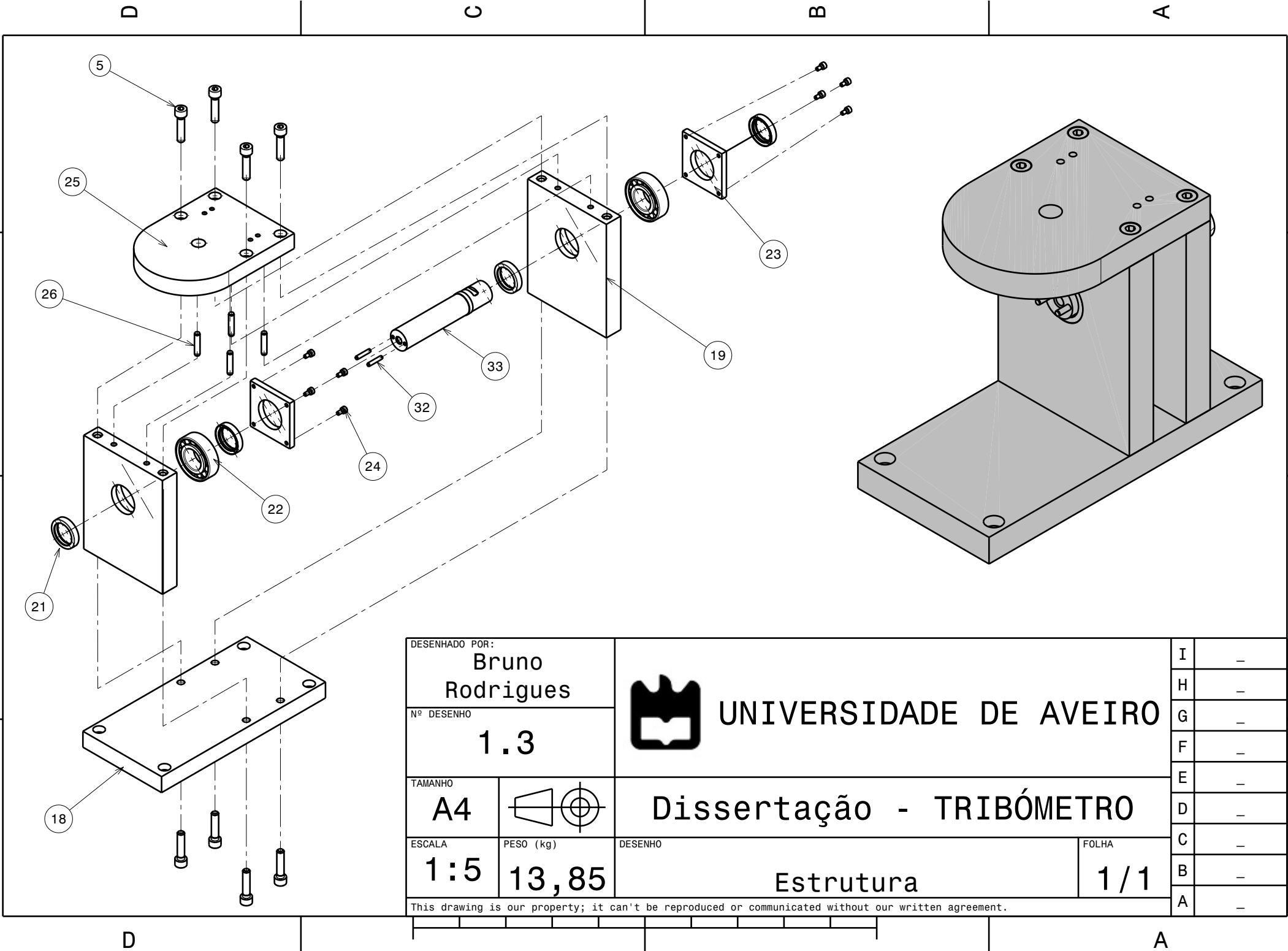
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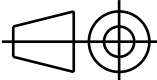
A




DESENHADO POR: Bruno Rodrigues		 UNIVERSIDADE DE AVEIRO	I	—
Nº Desenho 1.1			H	—
			G	—
			F	—
			E	—
TAMANHO A4		Dissertação - TRIBÓMETRO	D	—
ESCALA 1:10	PESO (kg) 83,34		C	—
DESENHO Tribómetro bloco-disco			B	—
			A	—
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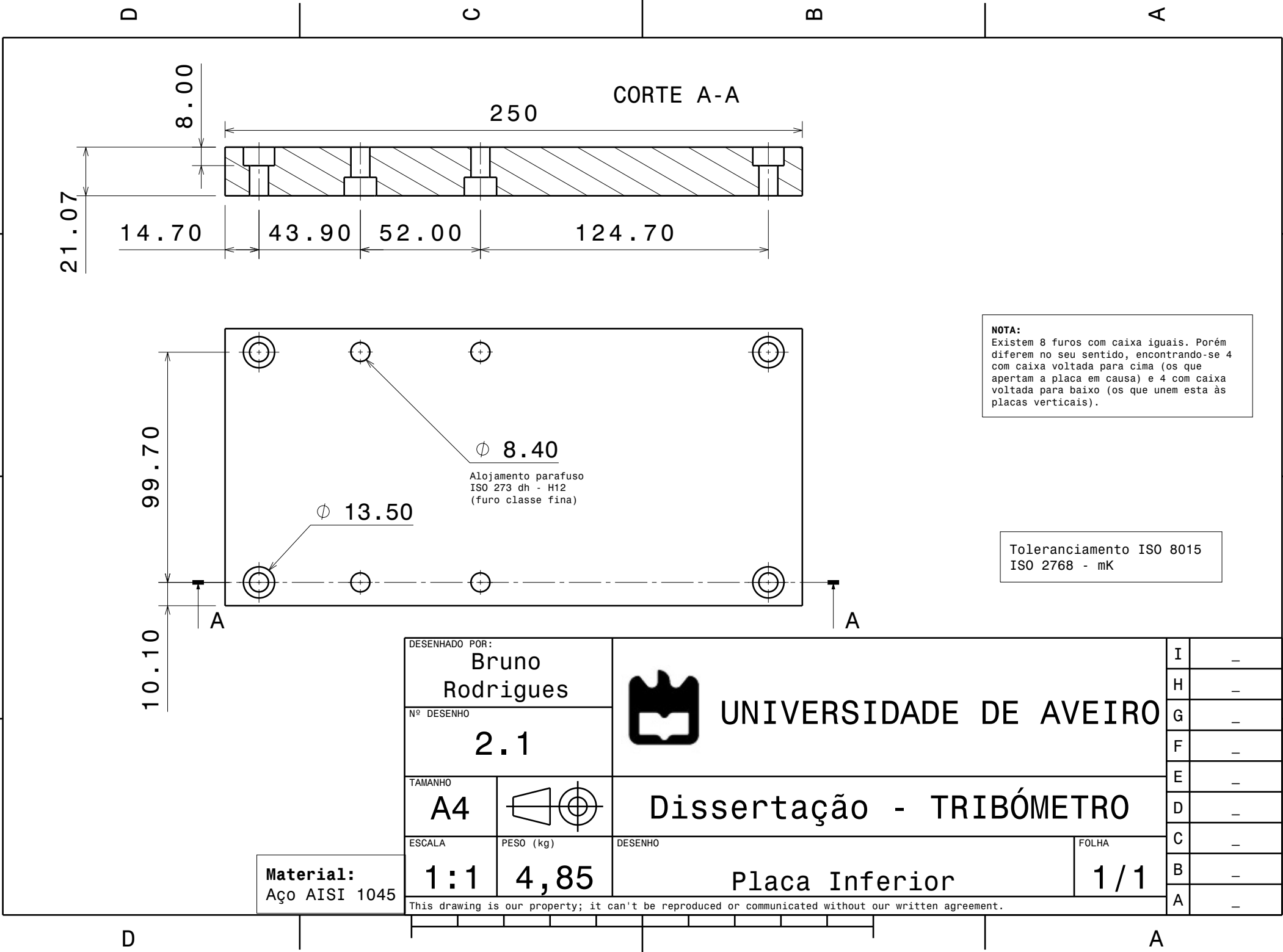


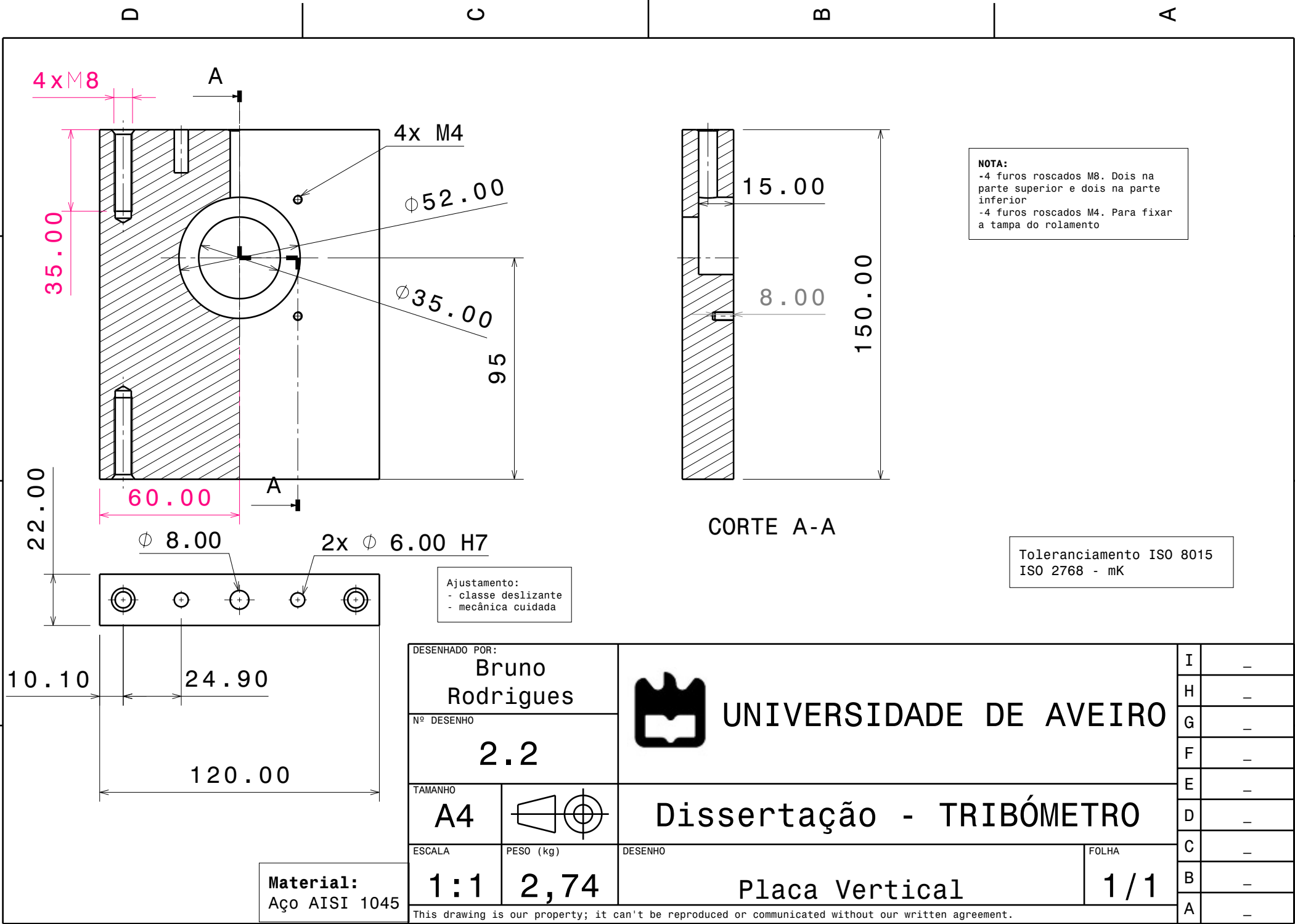
DESENHADO POR: Bruno Rodrigues	
Nº DESENHO 1.3	
TAMANHO A4	
ESCALA 1:5	PESO (kg) 13,85

	UNIVERSIDADE DE AVEIRO	
	Dissertação - TRIBÓMETRO	
	Estrutura	
	1 / 1	

I	-
H	-
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C	-
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A	-

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DESENHADO POR: Bruno Rodrigues	
Nº DESENHO 2.2	
TAMANHO A4	
ESCALA 1:1	PESO (kg) 2,74



UNIVERSIDADE DE AVEIRO

Dissertação - TRIBÓMETRO

Placa Vertical

1 / 1

I	-
H	-
G	-
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B	-
A	-

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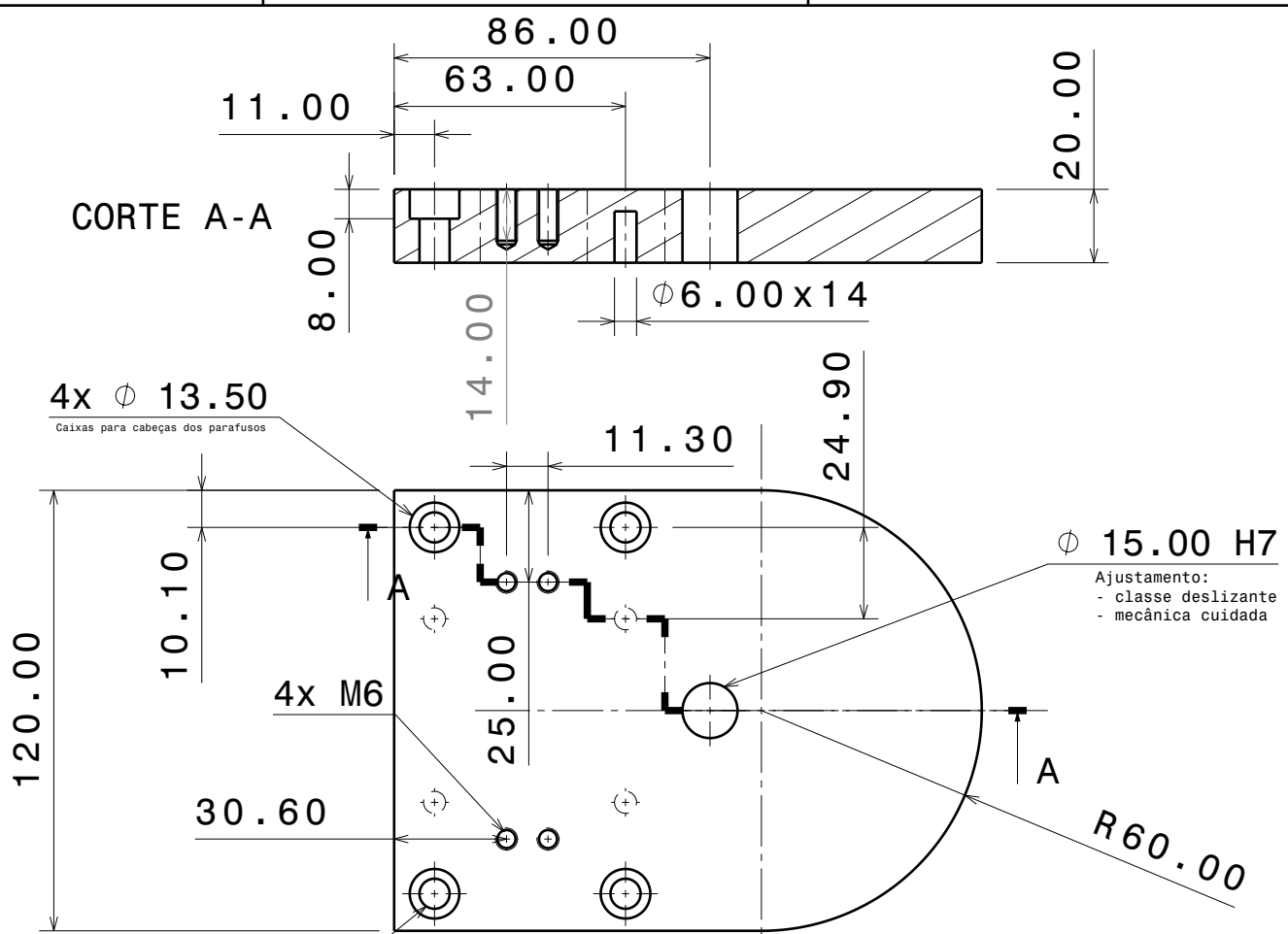
C

B

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D

A



Toleranciamento ISO 8015
ISO 2768 - mK

DESENHADO POR: Bruno Rodrigues	
Nº DESENHO 2.3	
TAMANHO A4	
ESCALA 1:1	PESO (kg) 2,67



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Dissertação - TRIBÓMETRO

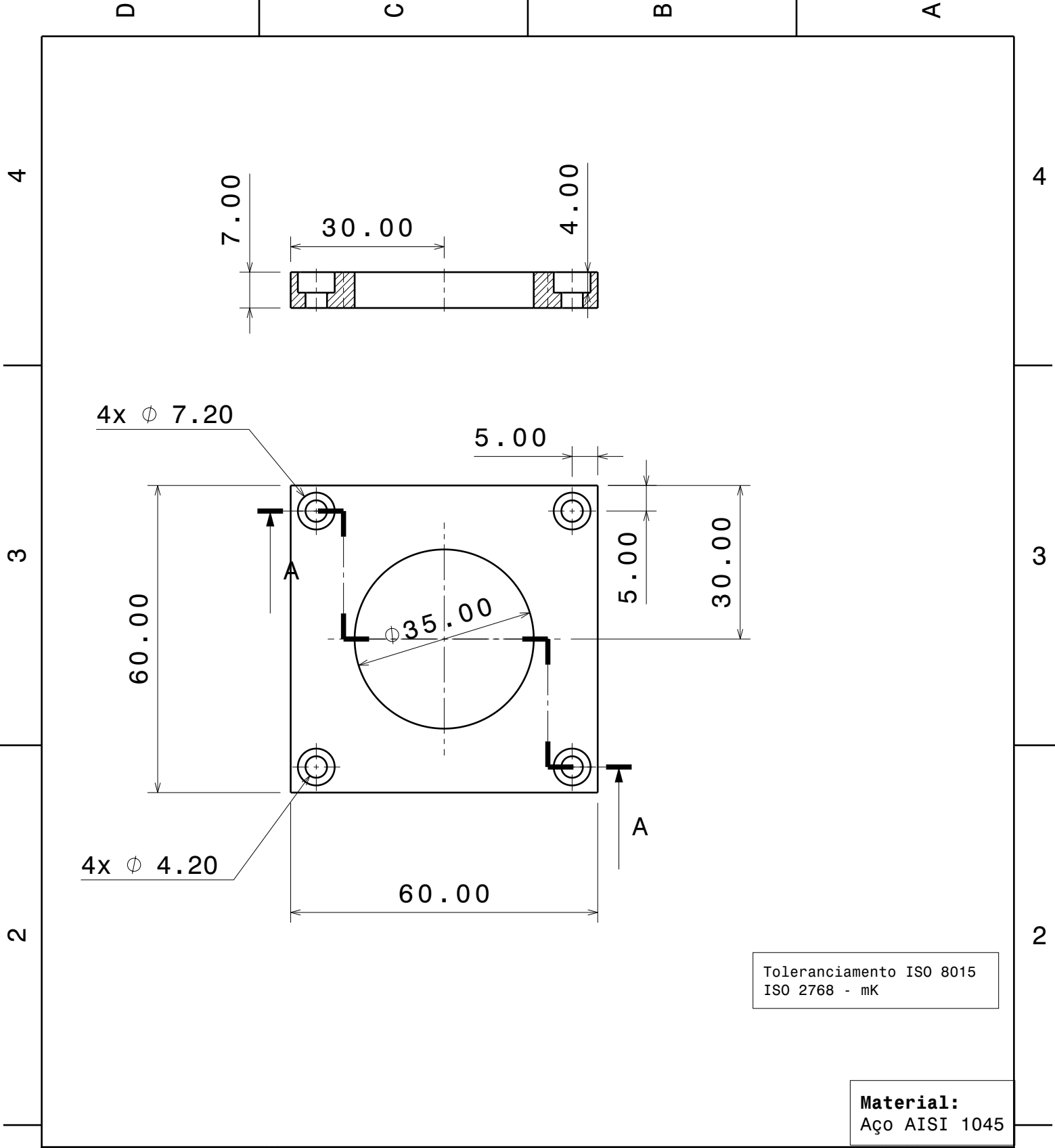
Placa Superior


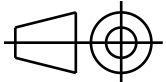
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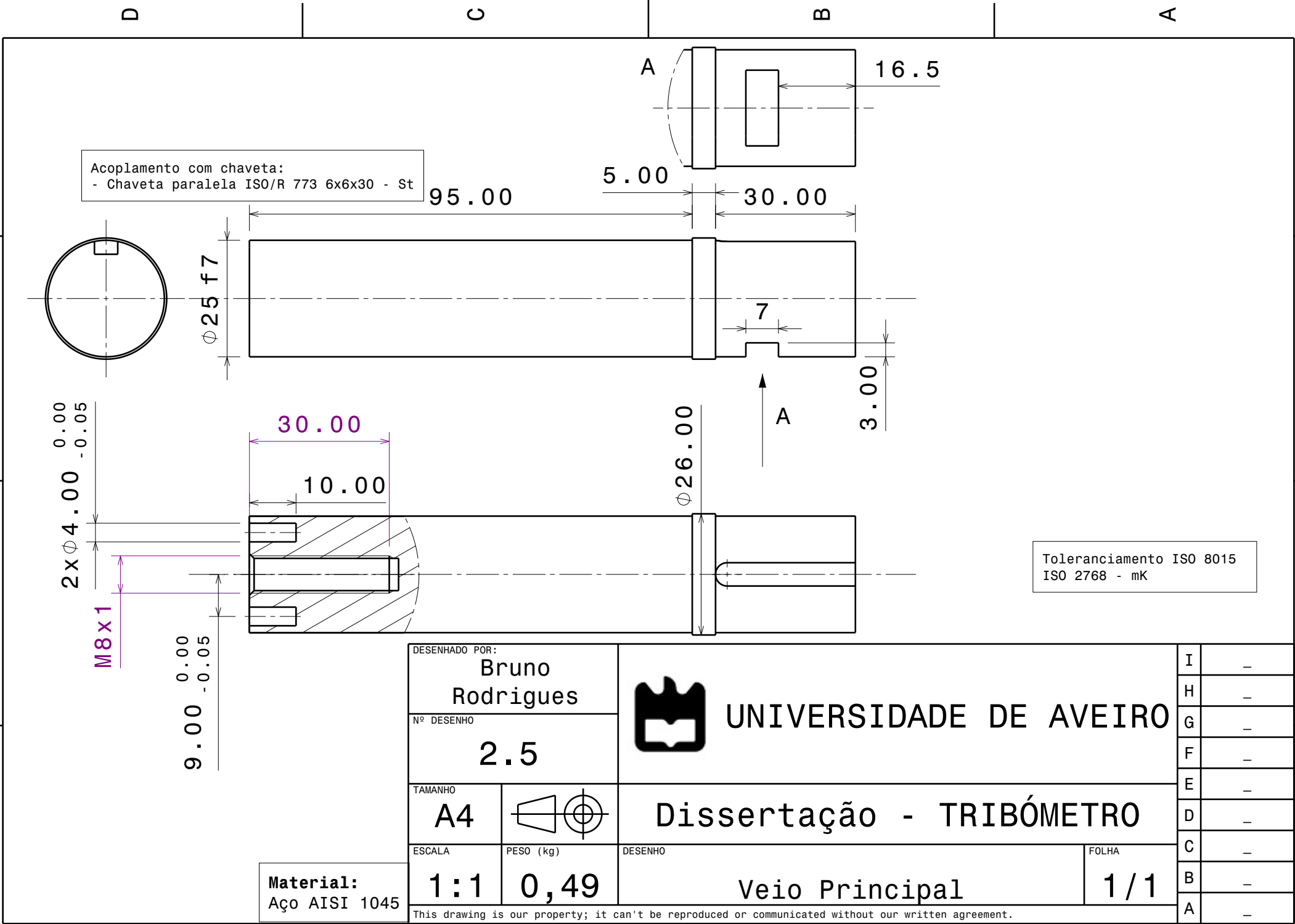
Material:
Aço AISI 1045

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I	-
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DESENHADO POR: Bruno Rodrigues			UNIVERSIDADE DE AVEIRO	I	—
Nº DESENHO 2.4				H	—
TAMANHO A4		Dissertação - TRIBÓMETRO		G	—
				F	—
ESCALA 1:1	PESO (kg) 0,14	Tampa Rolamento		E	—
				D	—
				C	—
				B	—
				A	—
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D				A	



DESENHADO POR: Bruno Rodrigues	
Nº DESENHO 2.5	
TAMANHO A4	
ESCALA 1:1	PESO (kg) 0,49



UNIVERSIDADE DE AVEIRO

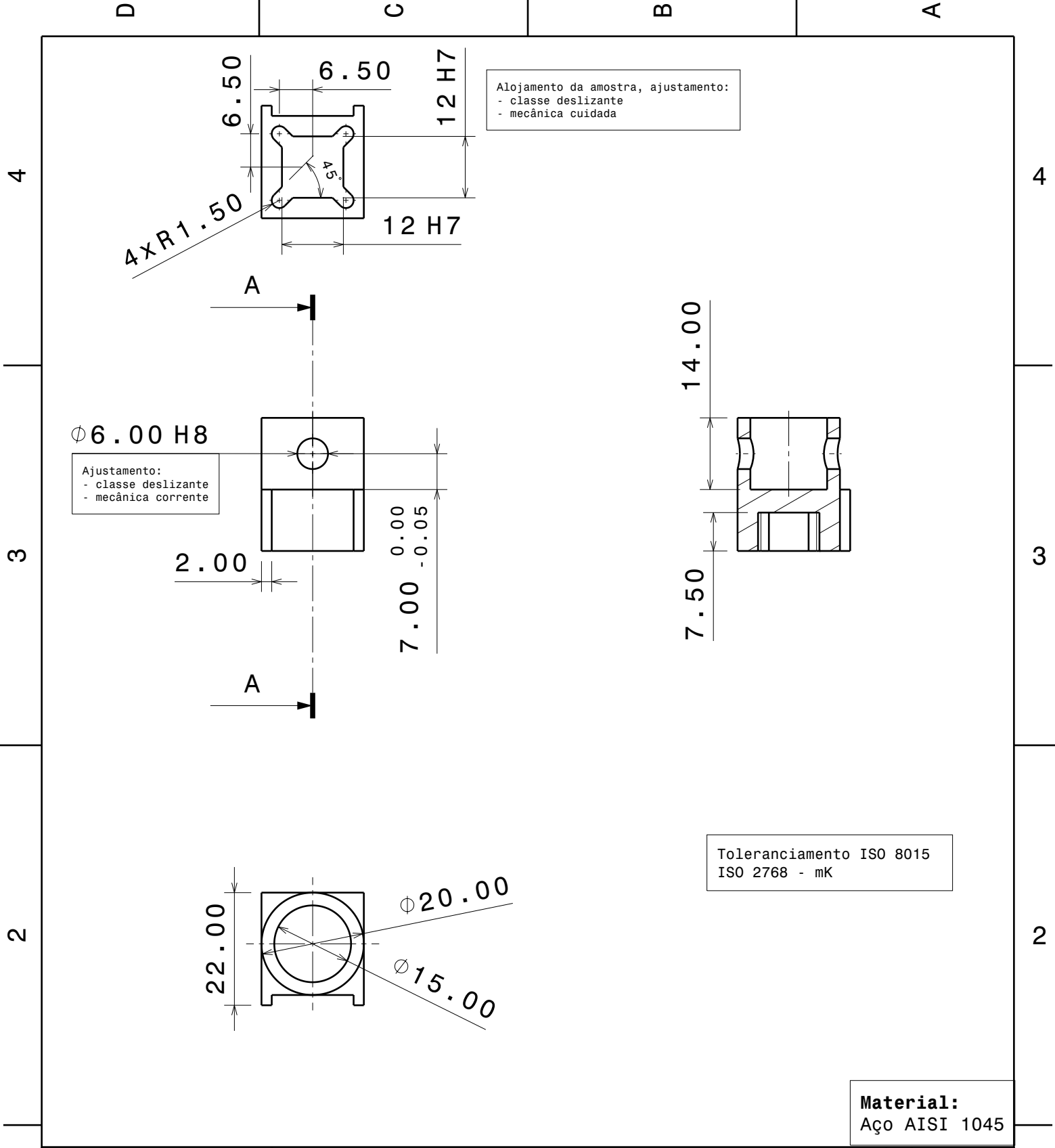
Dissertação - TRIBÓMETRO

Veio Principal

1 / 1

I	-
H	-
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E	-
D	-
C	-
B	-
A	-

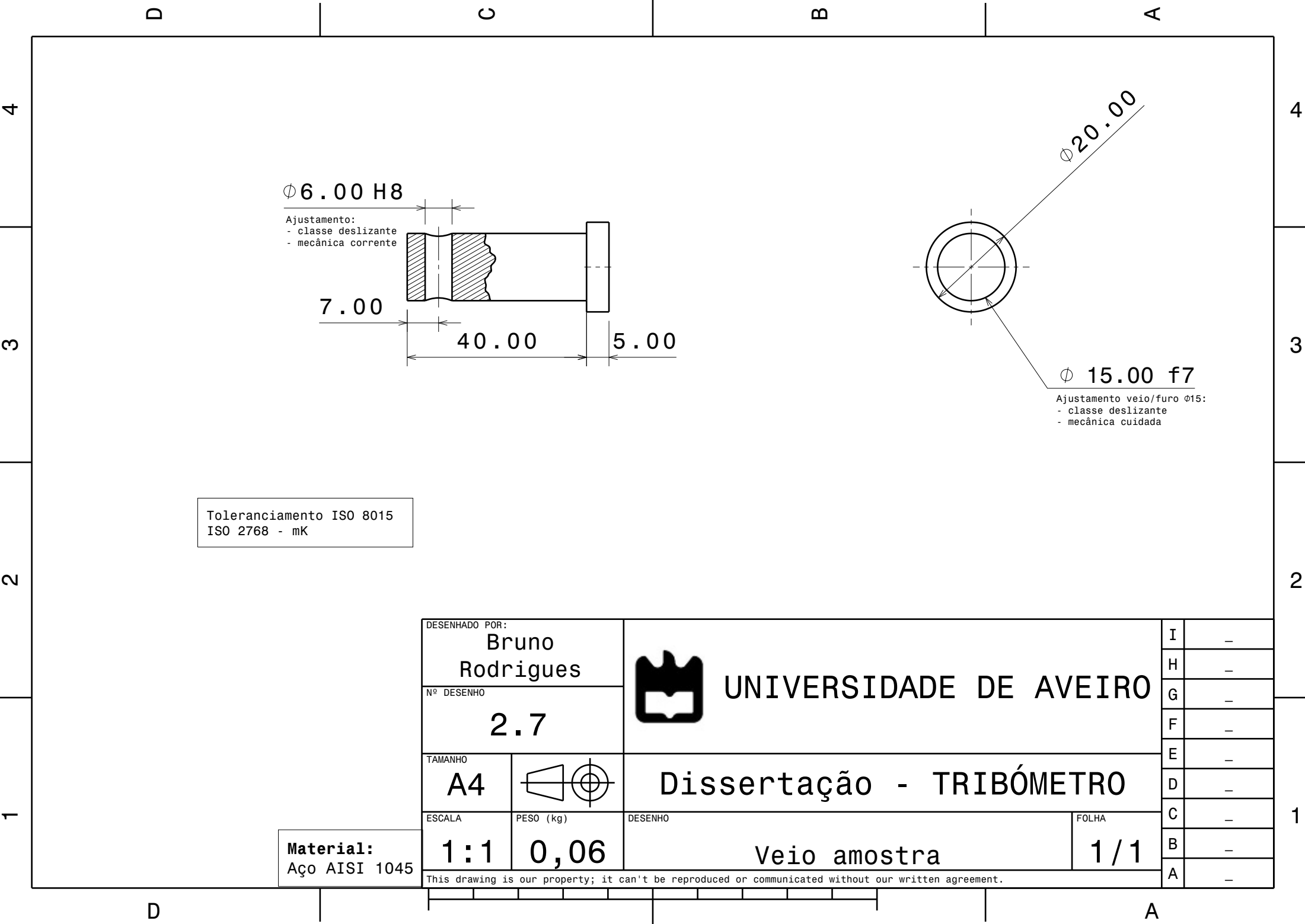
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DESENHADO POR: Bruno Rodrigues	
Nº DESENHO 2.6	
TAMANHO A4	
ESCALA 1:1	PESO (kg) 0,04

 UNIVERSIDADE DE AVEIRO		Dissertação - TRIBÓMETRO	
		Suporte Amostra	
FOLHA 1 / 1			

I	—
H	—
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F	—
E	—
D	—
C	—
B	—
A	—



Ø 6.00 H8

Ajustamento:
- classe deslizante
- mecânica corrente

7.00

40.00

5.00

Ø 20.00

Ø 15.00 f7

Ajustamento veio/furo Ø15:
- classe deslizante
- mecânica cuidada

Toleranciamento ISO 8015
ISO 2768 - mK

DESENHADO POR: Bruno Rodrigues			UNIVERSIDADE DE AVEIRO		I	—
Nº DESENHO 2.7			H	—		
			G	—		
			F	—	E	—
TAMANHO A4		Dissertação - TRIBÓMETRO			D	—
ESCALA 1:1	PESO (kg) 0,06	DESENHO Veio amostra			C	—
					B	—
					A	—
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D

C

B

A

4

3

2

1

15.00

6.00

7.50

12.50

11.75

40.00

15.00

23.50

Ajustamento veio/furo $\phi 15$:
- classe deslizante
- mecânica cuidada

 $\phi 15.00 H7$

Toleranciamento ISO 8015
ISO 2768 - mK

6.10

30.00

11.30

 $\phi 6.20$

Alojamento parafuso
ISO 273 dh - H12
(furo classe fina)

 $\phi 10.20$

Material:
Aço AISI 1045

DESENHADO POR:

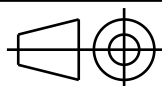
Bruno
Rodrigues

Nº DESENHO

2.8

TAMANHO

A4



ESCALA

1:1

PESO (kg)

0,12

DESENHO

UNIVERSIDADE DE AVEIRO



Dissertação - TRIBÓMETRO

Suporte Barra

FOLHA

1/1

I

-

H

-

G

-

F

-

E

-

D

-

C

-

B

-

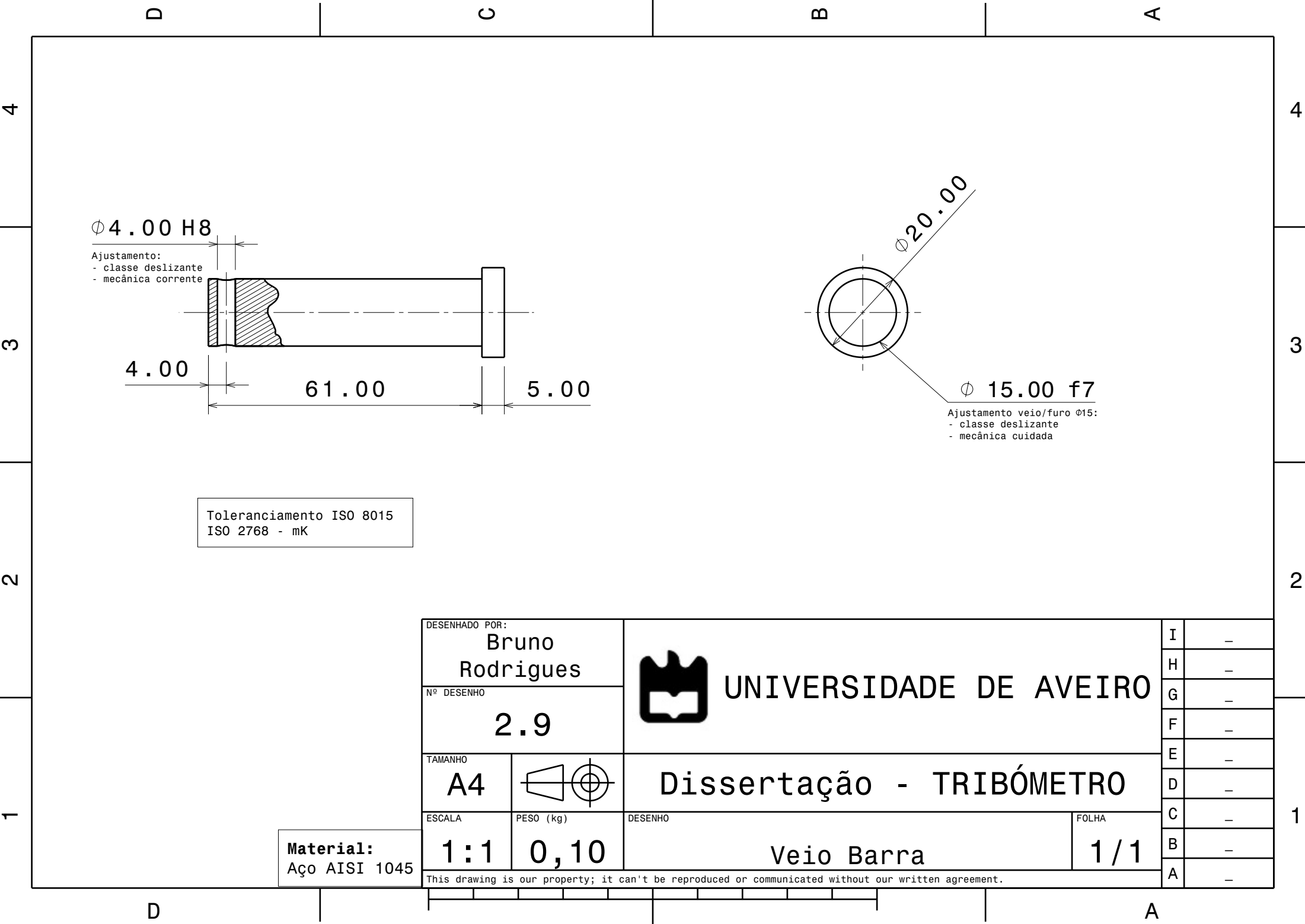
A


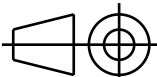
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D

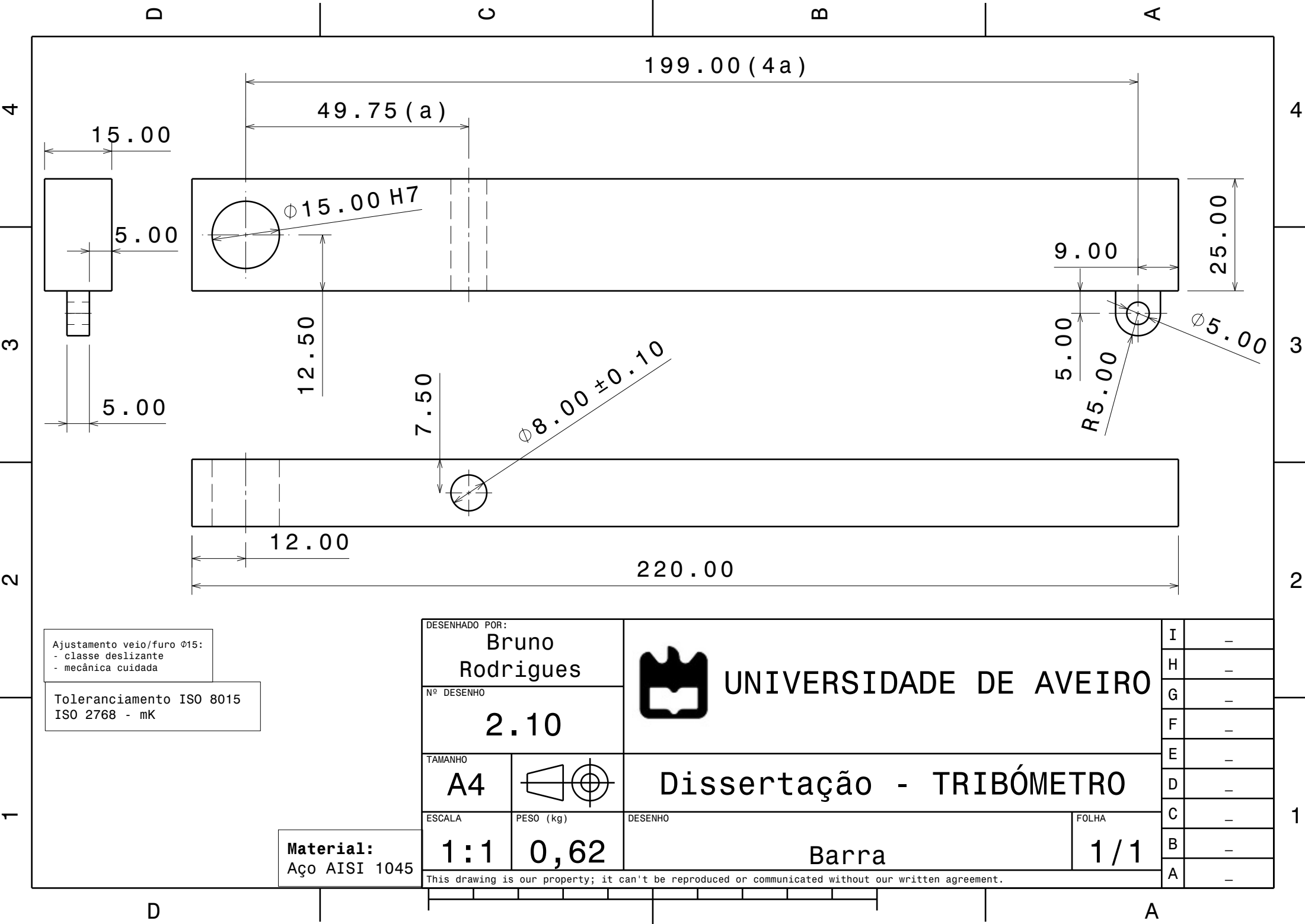
A



DESENHADO POR: Bruno Rodrigues		 UNIVERSIDADE DE AVEIRO	I	—
Nº DESENHO 2.9			H	—
TAMANHO A4		Dissertação - TRIBÓMETRO	G	—
ESCALA 1:1	PESO (kg) 0,10		F	—
DESENHO Veio Barra		1 / 1	E	—
			D	—
			C	—
			B	—
			A	—

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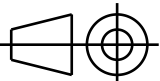
Material:
Aço AISI 1045



Ajustamento veio/furo $\phi 15$:
- classe deslizante
- mecânica cuidada

Toleranciamento ISO 8015
ISO 2768 - mK

Material:
Aço AISI 1045

DESENHADO POR: Bruno Rodrigues		 UNIVERSIDADE DE AVEIRO	I	—
Nº DESENHO 2.10			H	—
TAMANHO A4		Dissertação - TRIBÓMETRO	G	—
ESCALA 1:1	PESO (kg) 0,62		F	—
DESENHO Barra		FOLHA 1 / 1	E	—
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			C	—
			B	—
			A	—

4

4

3

3

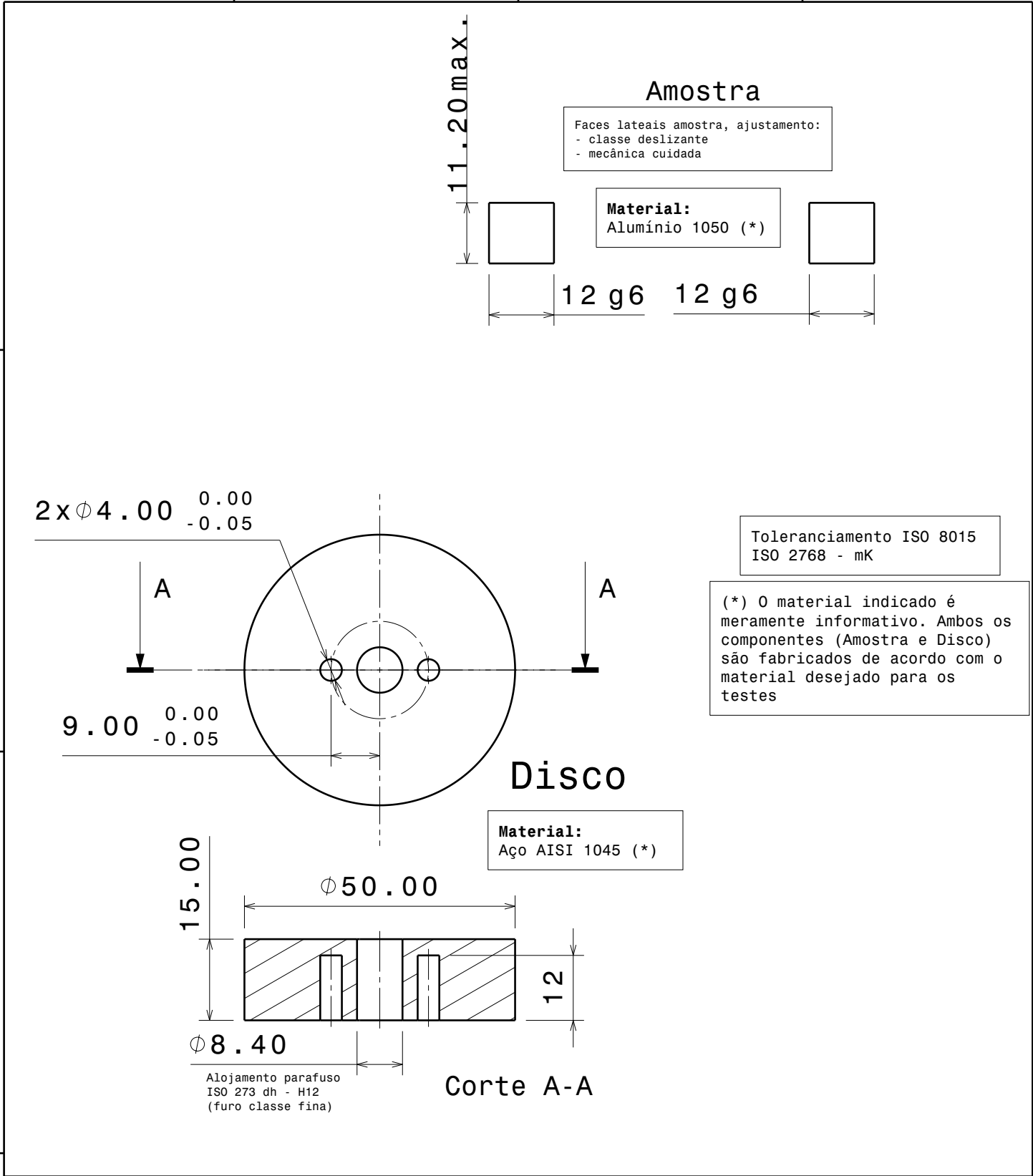
2

2

1

1

DESENHADO POR: Bruno Rodrigues		 UNIVERSIDADE DE AVEIRO	I	—
Nº DESENHO 2.11			H	—
			G	—
			F	—
			E	—
TAMANHO A4		Dissertação - TRIBÓMETRO	D	—
ESCALA 1:1	PESO (kg): AMOSTRA - 0,004 DISCO - 0,223	DESENHO Geometria bloco/disco	C	—
		FOLHA 1 / 1	B	—
			A	—
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D

A

ANEXO IV

Manual de Utilização do Tribómetro

MANUAL DE UTILIZAÇÃO TRIBÓMETRO BLOCO-DISCO

Introdução

Este manual destina-se a informar o utilizador do modo de funcionamento do tribómetro bloco-disco (Figura 1) de uma forma simplificada, apresentando todos os passos para a realização de ensaios.



Figura 1 - Tribómetro bloco-disco

Os principais parâmetros (a ser variados) utilizados são:

- Velocidade de rotação:
 - Varia desde 0 até um máximo de 1450 rpm, correspondente a 3,7 m/s
- Carga
 - Com barra: varia desde 15 N até ao máximo de 178 N (na amostra) quando utilizado todos os pesos mortos disponíveis
 - Sem barra: para cargas pequenas pode optar por excluir o sistema com barra o que permite uma carga mínima de 1,1 N.

Procedimento experimental

1. Ligar as tomadas do equipamento (tomada variador e tomada de comando-placa)
2. Ligar o botão start e regular a velocidade, através do potenciômetro, para a desejada. Observar a velocidade atual no LCD (Figura 2)
3. Desligar o botão start mantendo o potenciômetro na posição do passo anterior

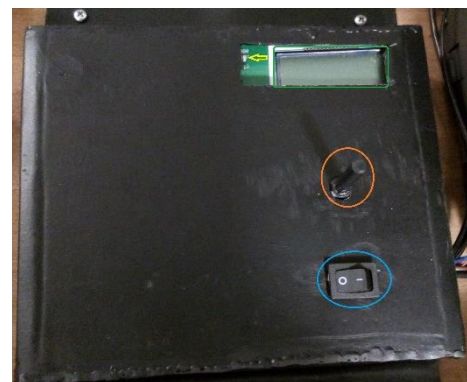


Figura 2 - Sistema de comando (Azul-botão; laranja-potenciômetro; amarelo-LED; verde-LCD)

4. Colocar o disco no devido lugar (Figura 3)
5. Colocar a amostra no devido suporte e montar o sistema (Figura 4)
6. Colocar os pesos desejados na barra (Figura 5).
7. Ligar novamente o botão start sem exercer pressão na amostra.
8. Após o motor estar na devida rotação, aplicar a carga de uma vez e iniciar a contagem (cronómetro)
9. Quando chegar ao tempo de teste necessário, desligar novamente o botão start

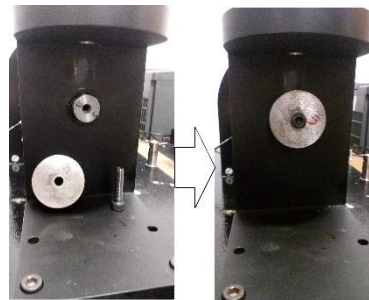


Figura 3 - Posição do disco no veio



Figura 4 - Colocação amostra

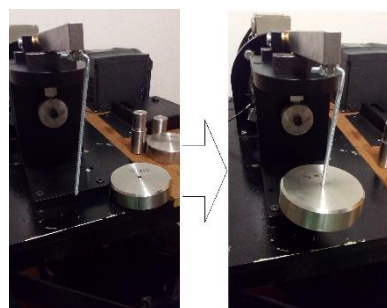


Figura 5 - Colocação dos pesos

Notas finais

- ✓ Neste tribómetro, a determinação do desgaste é dada pela perda de massa da amostra o que significa que é necessário pesar a amostra antes e depois do ensaio.
- ✓ Existe uma pequena luz LED ao lado do LCD (Figura 1) relacionada com a rotação do motor. Sempre que este conclui uma volta a luz muda de estado nesse instante.
- ✓ No caso de a marcação do valor da massa de cada peso desaparecer, estes podem ser distinguidos da seguinte forma:
 - Relativamente aos maiores (os mais largos) distinguem-se pelo chanfro. Aquele que apresenta chanfro menor corresponde a 1,675kg sendo o outro de 1,640kg.
 - Relativamente aos mais pequenos distinguem-se pela altura. Sendo que 0,357kg corresponde ao mais alto e 0,158kg ao mais baixo, logo o intermédio é de 0,330kg.

✓ Cargas possíveis:

Pesos	Massa (kg)	Sem barra [N]	Com barra [N]
P1	0,158	2,649	21,790
P2	0,330	4,336	28,540
P3	0,357	4,601	29,599
P1+P2	0,488	5,886	34,740
P1+P3	0,515	6,151	35,799
P2+P3	0,687	7,838	42,548
P1+P2+P3	0,845	9,388	48,748
P4	1,640	17,187	79,944
P5	1,675	17,530	81,318
P1+P4	1,798	18,737	86,144
P1+P5	1,833	19,080	87,517
P2+P4	1,970	20,424	92,893
P3+P4	1,997	20,689	93,953
P2+P5	2,005	20,768	94,267
P3+P5	2,032	21,033	95,326
P1+P2+P4	2,128	21,974	99,093
P1+P3+P4	2,155	22,239	100,153
P1+P2+P5	2,163	22,318	100,467
P1+P3+P5	2,190	22,583	101,526
P2+P3+P4	2,327	23,927	106,902
P2+P3+P5	2,362	24,270	108,275
P1+P2+P3+P4	2,485	25,477	113,102
P1+P2+P3+P5	2,520	25,820	114,475
P4+P5	3,315	33,619	145,671
P1+P4+P5	3,473	35,169	151,871
P2+P4+P5	3,645	36,856	158,620
P3+P4+P5	3,672	37,121	159,680
P1+P2+P4+P5	3,803	38,406	164,820
P1+P3+P4+P5	3,830	38,671	165,880
P2+P3+P4+P5	4,002	40,358	172,629
P1+P2+P3+P4+P5	4,160	41,908	178,829